MILK AND MILK PRODUCTS

A treatise on the treatment of milk and on the manufacture of milk products like butter, ghee, condensed milk, malted milk, casein, cheese, milk sugar, etc., etc.

BY

AN INDUSTRIALIST

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INTRODUCTION.

MILK and milk products are indispensable to the growth of the child and to the health of the adult For the infant, milk is a perfect food, for the growing child, milk and the products of the dairy industry are essential foods, and for adults and expectant mothers they are the most important foods. A seer of milk is equivalent in food value to nearly ½ seer of lean meat, 9 eggs, 10 chhataks of chicken or a seer of sole fish. Rich in first class proteins, milk is of special value to vegetarians It contains vitamin as well.

Yet it is a deplorable fact that the dairy industry in India is in a backward condition. Those who mainly carry on the industry do not realise its far-reaching influence on the physical, material and economic development of the people of the country and restrict their activities to the manufacture of ghee and butter and to that of chhana and curds on a smaller scale

European countries commanding a surplus of milk production over local consumption

have devised methods to utilise the excess supply in the best possible way They are making various milk products like casein, cheese, condensed milk, malted milk, etc, for their future use and export. In India, however, no such attempt has been made up-to-date.

CATTLE IN INDIA.

According to the cattle census of 1935, India possesses about 230 million cattle and buffaloes or about a third of the world's recorded number Of these about 455 lakhs of three-year old cows and 203 lakhs of she-buffaloes are kept for breeding or production of milk Goats of all ages and both sexes number 572 lakhs

Although India has as many milch cattle as Europe including Russia, the production of milk in India is only a fifth of that of Europe Compared with India, Canada produces 25 per cent milk, but with only about 6 per cent. of cattle in India.

MILK YIELD PER COW

The estimated annual yield of hand-drawn milk per cow in the different areas vary from about 65 lbs per annum in the Central Provinces, Eastern States and Bundelkhand States to about 1,445 lbs per annum in the Punjab, with an average of about 525 lbs.

for the whole country This amounts to about 1 lb 7 oz. of milk per day on an annual basis and to about 2 lbs 8 oz per day if the yield is taken on the basis of an average lactation of about 210 days.

It is generally observed that in the north and west the cows are better milkers, but as one gets to the south and east the milk producing quality deteriorates The best milking cows are reported to be in the canal colonies of the Punjab, embodying the districts of Lyallpur, Sargodha, Sheikhupura, Montgomery, Multan and Jhang The yield in these areas is reported to be about 5 lbs per day, or about 1,825 lbs per annum As a group, these cows are the best milkers in the country, but their number in the above districts is only about 6 lakhs or just about 1 3 per cent of the total cows in India.

LOCALISATION OF COW MILK PRODUCTION.

The production of cow milk is generally concentrated in the Indo-Gangetic plain and Eastern Rajputana Of all the provinces and States, the province of Punjab produces most milk and contributes about 15 5 per cent to the total production of cow milk in India. Such Punjab States as are located within the province produce a further 3 5 per cent Thus the entire Punjab area alone produces nearly a fifth of the total production of cow milk The

Rajputana group of States also produces 15.3 per cent. but the number of cows there is double that of the Punjab. The United Provinces produce a further 15 1 per cent whereas Bengal and Bihar contribute 11 and 8'6 per cent, respectively Sind and Central India States produce 4 2 and 3.8 per cent The above-mentioned northern, western and eastern areas together produce nearly 77 per cent of the cow milk in India and the remaining one-fourth is produced in other parts. Of this quantity, the Madras Presidency produces by far the largest proportion, i e, 7 7 per cent of the total Indian production.

MILK YIELD PER SHE-BUFFALO.

She-buffaloes do not do very well in the hilly tracts or where nutritious fodder is not available This accounts for the low milk yields in Bundelkhand (445 lbs. per annum), Kashmir State (570 lbs) and Assam (315 lbs) The best producers are in Western India States, particularly Kathiawar, where the average milk yield is 2,500 lbs per annum, equivalent to about 7 lbs per day throughout the year. The number of such animals is, however, small and is only about 3 7 lakhs Punjab has really the largest number (over 28 lakhs) of highest yielding animals, which are estimated to give about 2,320 lbs of milk per head per annum The average yield per

she-buffalo per annum for the country is 1,270 lbs. or about two and a half times that of cows (525 lbs).

LOCALISATION OF BUFFALO MILK PRODUCTION.

The production of buffalo milk is also concentrated in the Indo-Gangetic plain, excluding Bengal But the intensity is considerably greater and is more conspicuous than in the case of cow milk. The Punjab and Punjab State alone produce nearly 30 per cent of India's production of buffalo milk Bengal. which produces 11 per cent of India's cow milk, contributes less than 0 5 per cent to the total producion of buffalo milk On the other hand, the United Provinces produce over 19 per cent of buffalo milk against 15 per cent of cow milk.

MILK YIELD OF GOATS

On a moderate estimate the average milking goat gives 170 lbs. of milk per annum and the kid consumes about 50 lbs

QUALITY OF MILK

The milk of Indian cows and she-buffaloes is much richer in fat content than that obtained in countries abroad. This is a significant fact as, though the milk yield of our cattle may be low, the butter fat production is good

The fat content in herd milk of Indian cows ranges from 4 5 to 5 5 per cent according

to different breeds. The milk of Indian she-buffaloes is richer still and is perhaps the richest milk in the world from any dairy animal, with a fat content that ranges from 6 5 to over 8 per cent.

Goat milk in India is found to have a fat content of 4 to 5 per cent.

GROSS MILK OUTPUT.

The present annual gross production of milk in India amounts to 7,436 lakh maunds. Approximately 1,238 lakh maunds are consumed by the calves and kids directly from their dames Thus, the annual total production of hand-drawn milk is estimated at 6,198 lakh maunds and is valued at over Rs. 180 crores Of the total production, buffalo milk amounts to 50 per cent, cow milk 47 per cent and goat milk only 3 per cent. This is concentrated in the Indo-Gangetic plain, although milk is produced almost everywhere in the country.

Of all the areas the largest number of milch cattle is in the United Provinces but they do not produce the maximum quantity of milk. The credit for this goes to the Punjab. which with its States produces about 40 per cent more milk with only about 70 per cent of cattle in the United Provinces. The case of Bengal also is very striking It possesses practically the same number of cattle as the

Punjab but produces only about a quarter of the total yield of the latter province. On the other hand, Bihar which stands sixth in the list of cattle numbers stands out prominently as fourth on the basis of milk producion. The case of Baroda and Western India States also deserves mention, as they exceed in milk production, many areas having a much larger cattle population

Due to the incidence of calving, cow milk is abundant from February to April and again from November to December, buffalo milk from October to December, and goat milk in May and December. In the months of May, June and July, there is a comparative scarcity of milk throughout the country

CONSUMPTION OF MILK.

The quantities of milk retained by producers for domestic use vary from tract to tract. It is estimated that on an average, they keep back about 9 per cent for fluid consumption and about 8 per cent in the form of milk products The remaining 83 per cent or 5,083 lakh maunds of the net hand-drawn milk is put on the market either as fluid or as milk products.

The average daily per capita consumption of milk in India, including products, is estimated at 6 6 oz It varies considerably from tract to tract according to the production of

milk and density of population. Sind tops the list with 22 oz. per head per day followed by the Punjab with 19.7 oz. Assam has the lowest average consumption, viz., 1.2 oz only It has been observed that the peninsular area, notably the Madras Presidency, in spite of its low production compared with the population, exports large quantities of ghee to other areas which partly accounts for the low per capita consumption in that tract, e g , 3 oz. per day In this area the dairy cattle no doubt need improvement, but steps to conserve existing production for local use is a matter of even greater importance.

COLLECTION AND DISTRIBUTION OF MILK

Milch cattle are mainly owned in India by petty rural producers generally in lots of 2 or 3 The problem of assembling and distribution is rather acute. For instance, production in the country side takes place on a very small scale in innumerable and scattered holdings, which makes the task of collection difficult On an average, a village produces only 2½ maunds of milk per day and a major portion of it is converted into products or retained for family use by producers, leaving only a small quantity for sale. In the dairying tracts and round about cities, production is more concentrated but can hardly compare with the output per square mile in other milk

producing countries of the world. The above state of affairs has resulted in the dairy industry remaining in the hands of petty dealers with limited means and narrow outlook.

TRANSPORT OF MILK

As milk is a highly perishable and bulky commodity, it requires speedy, regular and cheap transport Being a fluid, it requires a some sort of special containers and careful handling during transport But suitable facilities for carrying milk are singularly absent with the result that milk produced in the interior cannot be economically brought for use in the cities This is a great handicap and restricts the sale of fluid milk, which is most paying to the producer.

The major portion of the milk produced is not transported at all and even in towns and cities about 60 per cent of the requirement is produced on the spot

The means of transport employed are rather primitive, e g, head-loads, shoulder slings, pack animals, bullock carts, boats and tongas Motor-lorries and trains are used only in a few cases Bicycles being cheap and speedy are quite popular. The transport actually used varies from tract and depends upon local custom, the quantity of milk handled and the distance which has to be travelled

NEW DEMAND FOR MILK PRODUCTS.

We thus have an excess supply of milk in villages and insufficient supply of the same in the cities where the deficiency is made up by imports. Condensed milk has secured a place on the shelves of the tea shops and the household kitchen. Foreign countries which have got an excess of the supply of milk have found out new uses for it and have devised methods by which milk can be preserved without any loss of its essential properties In India we are using them in big quantities in making tea at any part of the day In a like manner much of the excess milk in foreign countries is converted into malted food, casein and casein foods for the babies and it is their look-out that no part of the milk during the stage of manufacture is left unutilised.

POSSIBILITIES IN INDIA.

It devolves upon our industrialists to take a broad view of the whole situation. They can give a new orientation to the whole industry with a little constructive thinking and enterprise The essential point in any new scheme for bringing about a better distribution of the milk is to adopt methods of preservation as soon as the milking operation is over Milk thus treated will keep unturned for a longer period and will thus permit of collection at some stations, even long miles off from the

producing centres This will be of real benefit to the villages in more than one way This will not only improve the milk business and raise the price of milk but will at the same time bring about an improvement of the condition of cattle in India

Milk so collected can then be utilised for making a number of very useful products which are not as perishable as raw milk So long India has not taken up the manufacture of any milk products save and except butter, ghee and curds Chhana, khoa, etc are made in the country to some extent, but like milk these are also liable to ready decomposition and decay

It is time that India takes up in right earnest the manufacture of casein, condensed milk, lactose, malted milk, etc. In view of the rising demand for such articles, there is every reason to believe that the industry will be found promising and will at the same time bring employment to many an unemployed youth And what is more it will form the basis of an improved dairy business in India

The demand for these stuff must be very heavy There is hardly a household where they are not requisitioned daily in some form or other The production of India, albeit huge, is hardly able to meet the demand as is explained by the following table showing the import of these prducts:—

	1938-39	1939-40	1940-41	1938-39	1939-40	1940-41
	Quantity in 1,000 cwt			Value in lakhs of rupees		
Cheese ...	10	10	8	7	8	7
Butter ...	8	9	7	9	9	9
Milk Foods ..	10	11	7	18	23	16
Condensed & Preserved Milk ..	62	76	53	20	26	22
Ghee ...	47	55	—	—	—	—

It is a matter of surprise that India should be importing ghee from outside The imports are received from countries across the land frontier, most of it coming from Nepal, Tibet, Sikkim and Bhutan.

EXPORTS OF DAIRY PRODUCTS FROM INDIA.

The chief dairy product exported from India is ghee. The following table shows the quantity and value of the exports:—

	Quantity in cwt	Value in Rs.
1937-38	45,000	28,76,000
1938-39	44,000	27,81,000
1939 40	55,000	32,37,000
1940-41	44,000	31,23,000

CHAPTER II

COMPOSITION OF MILK.

NOTHING is of more importance to the manufacturer of milk products than the possession of a thorough knowledge about the composition of milk. In fact without this knowledge it is very difficult to follow the complicated reactions that occur spontaneously in the body of milk or are induced by the introduction of extraneous matters. This knowledge will thus stand in great stead in making the varied milk products of excellent quality.

PHYSICAL PROPERTIES.

Milk, when freshly obtained, is a white opaque fluid when seen in bulk, and has a characteristic faintly-sweetish taste and peculiar odour. The sweetness is due to its milk-sugar (lactose), the taste and odour can be best appreciated when they are absent, as in the case of heated milk which loses some of its fine flavour.) The so-called 'cowey' odour sometimes perceived in the milk is due to the absorption of characteristic odours from the atmosphere of cow-sheds and byres. To prevent this the atmosphere surrounding the milk

from the time it leaves the cow until it is consumed should leave nothing to be desired in hygienic quality—a circumstance easy of attainment and costing nothing but forethought.

The white colour of milk is due to the calcium caseinate it contains, and the opacity is due to the same substance and to fat. Sometimes, a more or less yellowish tinge is noticeable; that it is due to a pigment (lactochrome) associated with the fat of milk This pigment is different in the milk of different animals; it is yellowish in cow's milk and red in the human milk. During the colostral period and near the end of the period of lactation, milk may acquire a saltish or bitter taste and a rancid animal-like odour The odours vary in intensity from a slight saltish or bitter to an objectionably bitter flavour, the milk in extreme cases being quite unpalatable and unsaleable Abnormal odours may also be a result of the growth of bacteria in milk) Further, certain aromatic feeds also imparts their characteristic odour and taste to milk, such as rape, cabbage, beet, turnips, carrots, etc For whatever purpose the milk is required, and more especially when human consumption is concerned, it is of the highest importance that the milk should be of good natural colour, of attractive flavour and of undisputed quality

If milk is allowed to stand undisturbed for a time, its physical appearance soon

changes The cream rises to the top, forming a high solid and fat content and Pasteurization layer of 'skimmed milk' underneath The rapidity with which the cream may separate depends upon the size of the fat globules in milk, the temperature, and the density of milk plasma The separation of cream may be hastened by the process of centrifugation in which process, the fat being lighter than the other constituents of milk, rises rapidly to the top.

The specific gravity or density of milk ranges between 1 027 to 1 040, the average being 1 032 Viscosity or stickiness of milk is manifested by the adherence of milk to the sides of a glass vessel; it depends upon the milk solids, especially the casein. The more viscous a sample of milk is, the slower the fat in it will rise to the top. Dilution of milk with water reduces its viscosity, and creaming proceeds more rapidly, a fact of which advantage is often taken in butter-making Further, shaking reduces viscosity and allowing the milk to stand undisturbed increases it Cold milk has greater viscosity and cohesion than warm milk Viscosity is increased by age, low temperature, products of fermentation and a high solid and fat content Pasteurization reduces the viscosity of milk and cream

The freezing point of milk is 0 54 to 0 57 degrees Centigrade lower than that of water,

and is generally given as nearly 31 degrees Fahrenheit. When water is added to milk the freezing point rises. Boiled milk has a lower freezing point than raw milk.

The refractive index of milk serum varies from 1 3429 to 1 3445, and the specific heat of milk is 0.9457.

CHEMICAL PROPERTIES OF MILK

Chemically, milk is composed of all the essentials of a complete food to meet the requirements of young mammals Some of the constituents of milk are simple, others very complex in their chemistry Some of these are in true solution, others in suspension, and still others in emulsion The dissolved and suspended constituents are put under the term 'plasma solids' which, on coagulation, separate into milk serum and coagulum The fat is present in an emulsified state and in the process of coagulation. Casein which is normally in suspension, thickens and settles down. carrying with it the undissolved substances, and leaves milk serum in which soluble salts, lactose, certain proteids. ferments. colouring matter, etc., are present

In its structure, milk appears to be homogeneous but, in reality, it consists of a number of substances, some of which are in true solution while others are simply held in suspension It is a mysterious fluid containing about 101

different substances and no amount of skilful blending of the known constituents will produce a liquid equal to natural milk. There are 19 amino acids in its proteins, 11 fatty acids in its butter fat, 6 vitamins, 8 enzymes, 25 minerals, one sugar (lactose), 5 phosphorus compounds and 14 nitrogenous substances are suspended or dissolved in the natural water content of milk

Broadly speaking, the various constituents of milk may be put into distinct groups of compounds These are.—

(A) Water
(B) Casein
(C) Fats
(D) Milk-sugar or Lactose
(E) Albumin
(F) Mineral matter or Ash

In addition to the above, milk contains certain other complex substances in small amounts, namely, carbon dioxide, oxygen, lecithin, cholestrin, pigment, vitamins, enzymes, leucocytes, fibrin, etc, but they are not of any great importance in practical milk inspection Sometimes traces of certain volatile substances derived from food and drugs administered to the animals for therapeutic purposes may also be recovered in milk

Roughly speaking, milk may be divided into two parts, *water* and *milk solids* contain-

ing the rest, some of which exist partly in solution, partly in semi-solution and partly in suspension in water. Water comprises approximately 87 3 per cent of the total, while solids make up the remaining 12 7 per cent. The sugar, proteids and ash are sometimes called the *solids-not-fat* or *serum solids*

Another method of stating the composition is to divide milk into *fat* and *milk serum* or *skim-milk,* the latter consisting of all materials found in milk excepting fat

The best method of giving the composition of milk is as follows.—

	Per cent
Water	86 60
Casein	3 40
Fat	3 25
Milk-sugar	4 55
Albumin	.45
Ash	75
Total	100 0

PROTEINS IN MILK.

There are two chief proteins in milk, viz Casein and Lactalbumin.

CASEIN occurs extensively in milk secretions It forms nearly 20 per cent of the solid contents and about 85 per cent of the proteid content of milk Casein is precipitated from

milk by the addition of dilute acids and by certain enzymes as pepsin and rennin (chymosin). It is insoluble in water and in alcohol when free, but in milk it is combined with calcium in the form of calcium caseinate This later compound is responsible for the white colour of milk

LACTALBUMIN comprises nearly five per cent of the total solids of milk. It is in solution in milk and is similar to albumin in blood, but differs slightly in its chemical composition It begins to coagulate at 65 6°C, and once precipitated it will not redissolve in water although it is soluble in alcohol Common cheese contains very little of albumin as it is not precipitated by rennet and remains behind in whey Italian cheese, which contains albumin instead of casein, is made from whey

Other complex proteids also exist in milk but they are not of such importance as to demand serious attention

FAT IN MILK

The milk-fat also called 'butter-fat,' is a mechanical mixture of several different fats and is present in milk in an extremely finely divided condition, i e, in an emulsion Under the microscope it can be seen in the form of small transparent globules varying in size from 0 0016 to 0 01 mm in diameter In India, Gir cows and Murrah buffaloes have large fat

globules Milk with small fat globules is good for cheese-making and market purposes. Hariana cattle have small-sized fat globules The size of the fat globules depends much upon the breed, stage of lactation and feed of the animal; in goat's milk they are relatively small During the first few months of milking, the fat globules are large but few; towards the end of the period of lactation they become smaller but more numerous

The specific gravity of milk-fat on an average is 0 91, and therefore, when milk is allowed to stand undisturbed, the fat-globules rise to the top forming a layer called 'cream layer' When cream is removed by hand or by a 'separator' the fluid remaining behind is called 'skim milk' or 'separated milk' It may be further noted that the specific gravity of the fat is lighter than any other constituent of milk Moderately high temperatures favour the separation of fat from milk, and hence for its separation the milk is usually warmed to nearly 90 deg F On the other hand, higher temperatures delay and entirely prevent the formation of the cream layer, and temperature above 158 deg F destroys the cream layer entirely The cream does not rise in 'homogenised milk' because in the process of homogenisation the fat globules are broken up into very fine particles Such milk is said to be

more palatable and digestible than ordinary milk Normal milk-fat has a melting point between 29 5 to 36 deg. C., and freezing point between 20 to 27 deg C Density of milk can best be tested with the help of a lactometer, a simple form of hydrometer.

COMPOSITION OF FAT.

Chemically, all fats are composed of three elements, carbon, hydrogen and oxygen, but in the different kinds of fats the proportion of these elements differs The composition of butter-fat varies according to the breed, age, period of lactation, feed, external conditions, etc Each fat has its own melting point, freezing point, specific gravity and other physical and chemical characteristics, and hence the physical properties of butter-fat, especially its hardness and softness, are dependent upon the proportion in which its principal fats are present The fats are really tri-glycerides of different fatty acids, some of which are soluble and volatile acids, while others are insoluble and non-volatile. The former give the butter its characteristic smell or aroma, and in addition, afford a practical basis for distinguishing pure butter from other artificial fats, like mutton and beef fats, cottonseed oil, coconut butter, vegetable ghee, etc Butter-fat usually contains from 8 to 10 per cent of the soluble and volatile fatty acid

group of fats, whereas other fats contain only from 1 to 3 per cent. The 3.5 per cent. of fat, or thereabouts, usually present in milk is made up in the following way:—

Dioxystearin	1.04 p.c.
Olein	33.95 „
Stearin	1.91 „
Palmitin	40.51 „
Myristin	10.44 „
Laurin	2.73 „
Caprin	0.34 „
Caprylin	0.53 „
Caproin	2.32 „
Butyrin	6.23 „

The first six composing the list are insoluble and non-volatile while the rest are soluble and volatile.

LACTOSE

Lactose or milk-sugar comprises nearly 38 per cent. of the total solids present in the milk. Scientists are of opinion that lactose is the only carbohydrate present in milk. Milk-sugar prepared from milk of different animals has practically the same properties.

Certain bacteria split up lactose into lactic acid and certain by-products, like hydrogen, carbon dioxide, formic acid, butyric acid, etc. In the natural souring of milk the lactic acid bacteria break down lactose to form lactic acid.

However, the conversion is not direct, for the lactose is first changed by enzymes into glucose and lactose from which the lactic acid is produced. The presence of this acid is detected by the sense of smell when it has developed up to the extent of 0.2 to 0.25 per cent and from 0.25 to 0.3 per cent the acid will cause the milk to taste sour. When 0 8 to 1 0 per cent of lactic acid is formed as a result of decomposition of sugar by lactic acid bacteria, the strong acid medium becomes unfavourable for the lactic acid bacteria to live in and they cease to break down any more lactose But when some of the acid is neutralised, they will become active again The effect of lactic acid is to sour or 'ripen' milk, and so impart a flavour to the products like butter and cheese made from it

MINERAL MATTER OR MILK ASH.

The mineral salts present in milk are commonly spoken of as the 'ash' or 'mineral matter' Ash is a white material left after complete evaporation and burning of a sample of milk, and is the most constant constituent of milk, and its amount ranges between 0 7 to 1 per cent

Milk ash is composed of the following elements —

Potassium, sodium, calcium, magnesium, iron, phosphorus, chlorine, sulphur, carbon,

hydrogen and oxygen with minute traces of flourine, iodine and silica These elements are present in the form of compounds which are very useful for the nourishment of the young, especially for the formation of bones and teeth Some of these compounds are soluble in water, like chlorides, citrates and some phosphates of potassium, sodium and magnesium, while a portion of the phosphates appears to be in the form of very fine particles in suspension in milk A part of calcium and phosphorus salts are insoluble *Soldner* has given the following table representing the percentage composition of the ash of milk.—

	Per cent found in ash
Sodium chloride	10 61
Potassium chloride	9 17
Mono-potassium phosphate	12 77
Di-potassium phosphate	9 22
Potassium citrate	5 47
Di-magnesium phosphate	3 71
Magnesium citrate	4 05
Di-calcium phosphate	7 41
Tri-calcium phosphate	8 90
Calcium citrate	23 56
Calcium combined with casein	5 13

The salts of milk are indirectly derived from food and drinking water Sodium phosphate if given in large quantity with food,

may be recovered in milk, while sodium chloride passes through only in small quantity.

ADULTERATION OF MILK AND DETECTION.

The common frauds practised by the milk dealers are the addition of water and the subtraction of a part of the cream Sometimes rice starch sweetened with sugar or *batasa* is added to the milk to make up its specific gravity which falls down due to addition of water

The usual practice of determining the quality of milk by means of a lactometer is therefore, misleading. Because it is nothing but a mere hydrometer and its readings are neither more nor less than specific gravities The more milk-sugar, and casein, and mineral matter there is in a given specimen of milk, the greater will be its density or specific gravity, and the higher the lactometer reading Hence, the only reliable method of determining the quality of milk is its complete analysis involving the determination of the water, the fat, the casein, milk sugar and mineral water

ANALYSIS OF MILK.

The following is an outline of *Prof Wanklyn's* method of analysis —

By means of an accurately graduated pipette first place 5 c.c of the milk in a small weighed platinum dish (about 14 grms

in weight), having just previously ensured that the sample from which the milk is taken is thoroughly mixed.

The dish is then placed over a water bath (the water in which must be kept vigorously boiling the whole time) for 3 hours, at the end of which time all the water having been driven off, there will remain in the dish a completely dried-up residue.

The increase in weight between the empty dish and the residue will give the weight of the milk solids from 5 c c of milk Of course, if this weight be multiplied by 20, the yield from 100 c c of milk will be obtained

To reduce this to a percentage statement, it is necessary to remember that 100 c c. of average milk weighs 102 9 grms

To determine the fat content treat the dried milk solids resulting from the 5 c c. of milk with ether The whole of the fat should be dissolved by the ether, and being separated from the non-fatty portion of the residue, is weighed and calculated as " fat " If then the amount found as 'fat' be deducted from the whole of the 'milk solids' previous to their treatment with ether, the 'milk solids,' not fat, will be arrived at

The casein content including the entire nitrogenous materials of milk is estimated thus:—Treat the milk solids, not fat, with hot alcohol, which dissolves out from them the milk

sugar and the soluble chlorides The remaining residue, consisting of casein and phosphate of sodium (chemically combined with the casein), is dried on a water-bath until it ceases to lose weight It is then, weighed along with the vessel containing it, and ignited The combined weight of the vessel and phosphate of sodium remaining after ignition being deducted from the weight previous to ignition, the difference is the casein

The alcoholic solution, filtered off from the combined casein and phosphate of sodium, contains the milk-sugar and soluble chlorides. It is evaporated to dryness on a water-bath, and the residue with the vessel containing it is weighed. It is then gently ignited, and the weight of the remaining residue, being deducted from the total weight before ignition, gives the yield of milk-sugar Or the milk-sugar may be determined by titration with a standard copper solution

For the determination of the ash it is only necessary to ignite the milk solids from 5 c c of milk in the small platinum dish, by which operation all the organic matter being burnt, that which remains behind constitutes the 'ash,' and is weighed as such

CHAPTER III

MILK PRODUCTS.

VARIOUS are the preparations made from milk to suit human taste and for application in various arts and industries. On an average about 23 per cent of the milk produced is converted into milk products. On a moderate estimate 58 p c of milk output in India is made into ghee, 5 per cent each into khoa and curd Butter and cream account for only 1.9 per cent. and *rabri*, *malai*, etc 2.8 p c. At present only ½ p c. of the production is used for ice-cream.

A broad classification of the milk products with short descriptions of their properties and characteristics will be found interesting here The main classes into which milk products may be grouped are:—

1 Cream.
2. Butter.
3 Ghee.
4 Condensed milk.
5 Casein.
6. Cheese.
7 Milk Sugar
8 Lactic Acid
9 Milk Powder.

10. Chhana
11 Curd.
12 Khoa Kheer
13 Malted Milk

CREAM.

When milk fresh drawn from the cows is allowed to remain at rest, it separates into 2 parts A whitish oleaginuous fluid collects in a thin stratum over the surface of the milk This is white, soft and rich in fat, and in fact it is one of the chief constituents of butter and ghee Cream is not only delicious to taste but is also very nutritious

By violent agitation of the milk, as in the process of churning, the fatty globules of the milk unite together, forming butter The liquid portion mainly consists of casein The separation of the butter is effected most readily when the cream has become slightly sour and coagulated by being kept a few days

When cream is suspended in a linen bag and allowed to drain, it gradually becomes drier and harder, by the separation of the liquid portion, and then forms what is known as 'cream-cheese.' By the application of slight pressure the separation of the whey is more completely effected, and the product is not only better but will keep longer.

From a dietetic point of view cream may therefore be regarded in the same light as

butter, as it is converted into butter in the process of digestion.

Fresh cream is used entirely in cities mainly by confectioners.

BUTTER.

Butter is one of the most important products that have milk as their basic ingredient. In fact its use in India is hardly surpassed by anything except raw milk, ghee, chhana or dahi. The production is estimated to be 50,000 lbs per day or 8 150 tons per annum.

Butter is a solid fatty substance obtained from cream by churning it. It has got a pleasant odour when fresh and is of equal colour throughout its substance.

Butter is a wholesome diet as it contains from 8 to 10 per cent. of the soluble and volatile fatty acid group of fats whereas other fats contain only 1 to 3 per cent.

Butter is taken with loaves and is obtainable in the market either in the raw state or in the salted condition Salted butter keeps longer than the unsalted variety.

Butter is made from the milk of both cows and buffaloes Butter made from these shows different properties and flavour. It is believed by the Ayurvedic practitioners that butter from cow's milk is tonic, cardiac, stimulant, invigorating, and stomachic but

butter from buffalo milk is sweetish, astringent, refrigerant, demulcent, generative of semen, alleviative of wind and bile.

Butter like other fats is insoluble in water, but is readily soluble in ether, carbon bisulphide, nitro-benzene, and acetone Butter-fat is decomposed under the influence of light, superheated steam, oxygen, mineral acids and certain micro-organisms when fatty acids and glycerine are produced The latter on further decomposition gives water, soluble acids, aldehydes, etc Butter is therefore stored under water. The fat also contains a small amount of lecithin, a phosphorised fat, which is the cause of fishy odour in butter on decomposition This fact is of importance from the commercial standpoint

In India butter is available in two varieties, viz *creamery butter* and *country butter*. Creamery butter is made from mechanically separated and churned cream and is usually coloured and salted Country butter is made by churning sweet milk or curd or by beating cream with hand without the use of a churn.

GHEE.

Ghee is obtained by melting butter and eliminating the traces of curd or casein which may still remain in the body of the butter It is otherwise known as clarified butter from which all the moisture has been driven off.

Over 3,594 lakh maunds of milk are used annually in its manufacture.

Like butter, ghee is mainly of two types. viz, cow's and buffalo's and has got characteristic properties of their own. Buffalo ghee is white while, the cow ghee is just yellowish.

Ghee is perhaps the most widely employed among the milk products in daily diet of Indians. It is very wholesome and used in making curries, confections and *mithais* and also in frying *loochies,* which are otherwise known as *pooris* Ghee also forms an important leaven in making *chapattis* at home.

Ghee, as an ingredient of food, is of inestimable value, specially to those who are strictly vegetarians and do not take eggs, fish or flesh. There is hardly another substance which can replace fish or meat without undermining health.

Adulteration of ghee is practised widely and various cheap inferior articles are used for the purpose Chief among them are animal fats, hydrogenated vegetable fats, oils, etc From dietetic point of view such adulteration reduces the fat content of the original product Now-a-days adulteration is being carried out in a scientific manner so that detection by chemical tests may not be possible. Blending with inferior type of ghee is also in large practice among the manufacturers

CONDENSED MILK.

In its natural form milk cannot be transported a long way off Again it is liable to sour during the transit Modern science has therefore invented methods by which milk can be despatched in the solid state from a distant country to another without the least chance of deterioration in the interval It is readily soluble in water and reproduces milk in every respect Condensed milk can therefore be defined as milk which has been evaporated to dryness and canned for future use.

Condensed milk may be of two types, viz, *sweetened* and *evaporated* The former refers to a product which is obtained by condensing milk sweetened with sugar while the latter refers to a product in the manufacture of which no sugar has been employed

Condensed milk may again be subdivided into *full cream* or *skimmed* In the full cream variety the milk has not been churned before subjecting it to condensation and the cream has not been separated from it The skimmed condensed milk is prepared from milk from which the cream has been skimmed off by churning

Condensed milk is a popular article in these days It is indispensable in making tea at off times when fresh milk is not available From the point of view of health full cream

condensed milk is almost as good as fresh milk but the skimmed variety which is made after the separation of the milk-fat for the preparation of butter is a much inferior product Apart from this fact, both the types of milk present the same properties as regards colour, taste, etc

An analysis of the standard condensed milk shows the following composition·—

Milk sugar	1 58	per	cent
Cane sugar	33	,,	,,
Fat	8 25	,,	,,
Albumin	17 96	,,	,,
Salt	1 95	,,	,,
Water	23 20	,,	,,

CASEIN.

Casein occurs in the milk of all animals It is now-a-days prepared in large quantities for application in numerous arts and industries

After milk has been churned for the separation of the cream for making butter, it is made into casein In cow's milk it is present to the extent of 2 to 4 5 per cent.

Casein is insoluble in water and in alcohol It is however soluble in alkalies such as caustic soda, caustic potash or soda ash In milk it is not in solution but exists in a fine colloidal suspension in combination with calcium It forms nearly 20 per cent of the solid

contents and about 85 per cent of the proteid content of milk Casein is precipitated from milk by the addition of dilute acids and by certain enzymes as pepsin and rennin

Fresh milk when heated to boiling point does not coagulate A thin membrane consisting chiefly of casein is formed on the surface but no real coagulation occurs

Uses of Casein

Casein is made exclusively for export, with little or none for internal consumption. During the ten years ending 1938-39, approximately 9000 cwt of casein were exported annually from India

It is estimated that 100 lbs of skimmed milk yield 3½ lbs of casein Casein industry absorbs, it is understood, about 3 5 lakh maunds of skimmed milk, which quantity is only about 7 5 per cent of the total skimmed milk produced annually

Casein prepared on a large commercial scale is used as a patent food About one quarter of the ordinary Cheddar cheese consists of casein

When obtained in a pure state, cow-casein is a white, amorphous, hygroscopic powder without taste or odour Human casein and casein from solipedes is more readily soluble than casein obtained from ruminants

The casein is used in varied arts and industries First of all, it is introduced in pharmacy as a means of nourishment. One very extensive use of casein is a substitute for celluloid which is so dangerously inflammable Together with formaldehyde, it forms plastic transparent substances of great cohesive power, which can be dyed, polished, and produced in any shape. It is the so-called artificial horn, which comes into the market in a variety of forms, such as galalith, etc In electro-technics it plays an important part as an insulating material Cylinders and plates for photography, as well as films, are likewise made of this material. Artificial tortoise shell, artificial amber, ivory, combs, and all kinds of objects in common use of the most various descriptions, in all colours, are derived from casein Super-calendered and photographic paper, wall-paper, and coloured paper are manufactured with the addition of casein, in order to attain a high glaze and be able to stand being immersed in water Soaps become softer and more durable, through the addition of casein Specially favourable qualities are exhibited by combining casein with lime, such as in the case of glue, which becomes capable of resisting dampness, and is therefore, used in ship-building, where ordinary glue cannot be used at all Casein is also used for manufacturing plywood Case-

in colours are also extensively in request for washes and painting, as well as for coloured varnishes which are very much in demand on account of their excellent covering power. In the printing of stuffs and in the linen industry casein furnishes the dressing material, and artists' canvas is impregnated with it Combinations of casein with other substances are also employed for loading silk Casein is even used for clearing wine Thus India cannot be too strongly urged to foster the manufacture of casein and to extend it as far as possible, because a commercial article of such multifarious usefulness will always remain marketable and will give a handsome return for the outlay

CHEESE.

Cheese is the curd of milk, salted, dried and compressed into a solid mass There are cheese of different varieties and qualities, the principal distinctions arising from differences in the composition and condition of the milk operated upon, from variations in the method of preparation and curing, and from the use of milk of other animals besides the cow Differences are still further increased, in some cases by adding cream to it, and in others by using it as skim-milk or milk deprived of a portion of its fat

The essential constituents of milk are the nitrogenous substance called casein and butter. The object of the cheese maker is to obtain in a solid form as large a proportion as possible of the casein and butter contained in the milk dealt with. The poverty in these constituents of the whey or liquid matter separated in the process of making cheese is therefore, to some extent, a measure of the success of the operation.

Milk, as is well known, if allowed to stand for some time, becomes thick, and is then separable into two portions—a solid white curd, and a greenish liquid whey. Such a coagulation and separation is essential in the making of cheese.

The excellence of cheese depends upon the degree to which ripening has been carried on It takes place as a result of a slow process of decay caused by a spontaneous fermentative action

Cheese when newly made has an acid reaction but by degrees from without inwards the acid reaction becomes less apparent, and the cheese ripens A portion of the casein suffers decomposition, evolving ammonia and ammoniacal bases which neutralise the acid of the cheese. In a similar way the fat is partly decomposed, and the resulting fatty acids also combine with the ammonia evolved by the

casein When this action is allowed to proceed too far, the cheese becomes alkaline, putrefactive decay ensues, free ammonia is evolved, an offensive odour is produced, and sometimes even poisonous compounds are formed A satisfactory indication of ripening is the appearance of a green mould, streaked throughout the mass, produced by the fungus *Aspergillus glaucus* A red mould also develops sometimes and when the ripening becomes advanced, the C-*mite* is produced in inconceivable numbers

As an article of food cheese is used in a double capacity Rich cheese in an advanced stage of ripeness is eaten in small quantities, partly on account of its piquancy and partly also as a digestive stimulant Skim-milk cheese and all the varieties poor in fat, again, are valuable articles of food on account of their percentage of nitrogenous matter, and the cheaper qualities are on this account, consumed among classes by whom other animal food is not usually obtainable As an article of ordinary diet, cheese labours under the disadvantage of being hard of digestion, and especially when it is toasted, as is frequently the practice, it really is "about as digestible as leather"

To mention a few varieties of cheese:—

Cream Cheese—A preparation of a soft, buttery consistency, made from cream gently

pressed, which must be used new and fresh

Milk Cream Cheese—A preparation of cheese made from unskimmed or whole milk to which cream churned from other milks has been added

Whole Milk Cheese—A preparation of cheese made from whole milk.

Skim Milk Cheese—This is made from milk from which the cream has been previously separated by churning

MILK SUGAR.

Milk sugar is made from the whey that is left after the preparation of casein or cheese It is an important ingredient in the making of homoeopathic globules This is also used in modifying milk for feeding infants and invalids, as a diluent in various strong drugs, in the preparation of medicinal powders and in the manufacture of penta-nitro-lactose which forms a part of some high explosives.

Sugar of milk occurs in white, translucent, very hard cylindrical masses or four-sided prisms, it is soluble in 6 parts of cold and in 2 parts of boiling water; nearly insoluble in alcohol and ether; ammoniacal lead acetate precipitates it from its solutions Milk sugar is not susceptible of the vinous fermentation, except under the action of dilute acids, which convert it into grape sugar; in solution it is

converted by fermentation into lactic or butyric acid by the action of casein and albuminous matter Milk contains about 5 per cent of milk sugar which is technically known as *lactose*

LACTIC ACID

Another valuable milk product is lactic acid—a sour, syrupy liquid discovered by Scheele in whey It is by no means an unimportant constituent of the human organisms It is contained in the gastric juice, and is frequently formed in the sweat. It has been detected in the saliva of diabetic persons

Lactic acid is soluble in water, alcohol and ether It exhibits the usual acid properties and forms salts with the metals, called lactates An aqueous solution of lactic acid may be concentrated in vacuo over a surface of sulphuric acid until it appears as a syrupy liquid of specific gravity 1 215 Heated in a retort to 130°C, a small portion distils over, and the residuum on cooling solidifies into a yellowish, compact, fusible mass of lactic anhydride, very bitter, and nearly insoluble in water

Lactic acid has got medicinal uses It has been given in dyspepsia, gout, phosphatic urinary deposits, etc. The leather industry is the principal consumer of lactic acid, utilizing probably 80 to 90 per cent of the entire consumption of the country Its most

important function in leather industry is the removal of lime from dehaired hides. The dyeing and finishing of textiles constitutes an important field for the use of lactic acid, particularly in chrome mordanting and in acid dyeing process as applied to wools.

In recent years a large amount of lactic acid has been used in the production of ethyl lactate, a high-boiling solvent for the nitro-cellulose used in the production of pyroxylin lacquers.

The edible and better grades of lactic acid are gradually finding increased uses in widely diversified lines of food and beverage products, some of which are infant foods, low-alcohol beers, soft drinks, candies, poultry, and stock foods. In infant foods, lactic acid appears to have a corrective effect upon the digestive tract; in beers its purpose is to improve their flavour and odour; in soft drinks and certain candies it acts as an acidulent replacing citric and tartaric acids

CHHANA.

Among the milk products which are made in considerable quantities in India, *chhana* occupies a very high place It enters into the composition of *sandesh, rasagollah* and very many dainty preparations It is a very popular article of food in Bengal but outside Bengal its preparation is only indifferently

known Taken with sugar it offers a most delicious and nourishing tiffin. It is rich in protein and has got bone-building properties.

Chhana is in fact a combination of milk solids effected not through evaporation of the moisture but by acid coagulation and subsequent drainage of whey.

Chhana is made from whole milk by curdling it with juice of lemons or citric acid. It is obtainable in white, soft, pulpy mass but is often adulterated or stiffened by the incorporation of rice starch or arrowroot

As in the case of cheese, chhana may either be made from whole milk or from skimmed milk That prepared from whole milk is of much superior quality to that prepared from skim-milk The former shows the presence of milk-fat or butter when rubbed between the fingers.

CURDLED MILK.

This is another Indian preparation of milk and is much esteemed in Indian homes for its delicious taste and beneficial action on the digestive functions Over 300 maunds milk per annum or about 5 per cent of the total production is marketed as curd In common parlance it is known as *dahi* or *dodhi*

It is prepared by stimulating lactic acid fermentation in milk by incorporation of old dahi or lactic acid ferment It occurs in

white thick lumps and may be either available in sweetened or raw condition. This has got an acidic taste and is rélished best with *Sandesh* After a heavy dinner it seems very palatable and digestive *Dahi* is also used in the preparation of fish curries and also in the making of whey.

KHOA.

Khoa or Khowa is the vernacular name applied to milk thickened to semi-solid consistency by the evaporation of its water This product contains about 20 to 25 per cent. moisture, the remaining being milk solids. It is finished in the form of balls or pats each weighing about 2 to 3 lbs.

For making khoa, milk is heated very slowly in a shallow thick boiling pan and as it is being heated it is stirred constantly in order to prevent the formation of skin and also to accelerate the evaporation of water As the water is evaporated the milk becomes thicker in consistency and the heating is stopped when it becomes semi-solid. Khoa properly prepared is white in colour and has good flavour Khoa contains all the constituents of milk but their proportions show marked difference.

Khoa is used for preparing many kinds of sweets. Pounded sugar, dry nuts, flavouring substances and sometimes colouring matter too

are added in preparing khoa sweets of different sizes and shapes

Khoa by itself does not keep well and fermentation sets in rather soon unless it is preserved with sugar.

Khoa prepared from milk of newly delivered cows keeps in good condition for a very long time

The flavour of the khoa depends upon the richness of the milk and the care taken in preparing it Market khoa is sometimes adulterated with starchy substances like arrowroot, rice flour, wheat flour, etc

USAGES OF MILK IN INDIA

The milk products annually require for their manufacture 45,10 lakh maunds of liquid milk as given in the following table —

	Consumption of of Milk in maunds	Consumption of Milk Percentage
Ghee	3,594,12,000	79 70
Khoa	310,11,000	6 87
Curd	309,92,000	6 87
Butter	101,22,000	2 24
Ice cream	23,54,000	0 52
Cream	21 38 000	0 48
Other products	149,78,000	3 32
TOTAL	4,510,07,000	100

PRESERVATION OF MILK.

MILK is subjected to various changes, such as souring, putrefaction, sliminess etc., which are the result of ferments acting upon the milk constituents and producing fresh substances Hence to keep the milk from turning sour, it should be preserved by some means so as to keep all its properties intact

The main thing to be noted in this connection is scrupulous cleanliness during the milking process The whole operation should be conducted in a neat fashion. The cowshed should be perfectly tidy and the utensils in which the newly drawn milk is to be placed should be cleaned, washed, and sterilised if possible The hands and dress of the milkmen should be clean so that the chances of the milk getting contaminated are greatly reduced

One of the most common and effective methods of preserving milk is to store it in stout bottles, cork them well and wire them down and finally to heat them in this state to the boiling point By this means the oxygen of the small quantity of enclosed air becomes absorbed It must be afterwards stored in a cool place By this method milk will

retain its properties unaltered for a long time A few grains of carbonate of magnesia, or still better of bicarbonate of potash may be advantageously dissolved in each bottle before corking it.

According to another process, the milk is scalded, and, when cold, strongly charged with carbonic acid gas by means of a soda-water machine, and the corks are wired down in the usual manner The bottles should be kept inverted in a cool place

An excellent method of preventing milk from turning sour, or coagulating is to add to each pint of it about 10 or 12 grains of carbonate or bicarbonate of soda Milk thus prepared may be kept for 8 or 10 days in mild cold weather This addition is harmless, and, indeed, is advantageous to dyspeptic patients

Milk should not be kept in lead or zinc vessels, as it speedily dissolves a portion of these metals, and becomes poisonous

PASTEURIZATION OF MILK

The practice of pasteurization of milk is being followed by some dealers who find that it greatly reduces the number of complaints they receive on account of sour milk, specially when milk is to be carried to distant places

The object in pasteurizing milk is to destroy disease germs which may get into the milk

either from a diseased cow or in some other way. The germs of tuberculosis, diphtheria and other diseases are rendered harmless by proper and thorough pasteurization. The pasteurization of milk is thus desirable when the milk contains large number of harmful bacteria, and especially when it is thought to contain pathogenic or disease producing bacteria Milk which has been pasteurized should be kept longer than 24 hours before being used

The treatment consists of heating the milk to between 140°F and 160°F, at which temperature a large number of bacteria in the milk are killed, and then cooling it to check the growth of others. If sufficient heat were used to kill all the germs the product would be called sterilized milk, and it might be kept in good condition indefinitely. Unfortunately the higher heat renders milk objectionable to many consumers, as it changes its taste and appearance, and perhaps slightly reduces its nutritive value

PASTEURIZER.

The operation of pasteurization is a combination of heating and cooling The apparatus in which milk is heated is called the "pasteurizer" and that in which milk is cooled a "refrigerator" Pasteurizer is a cylindrical metallic vessel with a steam jacket all round,

a lid, a fan, and, there is an inlet for steam at the rim, and an outlet at the bottom, and these communicate only with the steam jacket The inlet of the milk in the vessel is at the bottom and the outlet is at the rim The arrangement is exactly opposite of what it is in the refrigerator The fan is worked by means of either steam or cool water turbine There is also an arrangement for noting the temperature of milk as it leaves the machine When the machine has to be worked, the fan and lid are fitted up, steam opened into the jacket, the fan is set in motion and when it attains its full speed milk is admitted into the machine By the rapid circular motion of the fan a sort of whirl-pool of milk is formed and milk rises from bottom to top in a thin layer along the sides of the vessel, and as it rises its temperature is raised as there is only the metal of the vessel between milk layer and steam In this way the uppermost portion of milk attains the highest temperature as, it leaves the machine Generally the temperature of milk is raised to 140° to 176°F and by regulating the current of steam and milk the temperature of milk can be raised to any desired degree Milk as it flows out of the pasteurizer is admitted into the refrigerator where its temperature is lowered to 55° to 60°F After cooling the milk is put into cans

CONTINUOUS PASTEURIZERS.

Special kinds of apparatus are used for pasteurizing milk on a large scale. Those generally preferred are known as continuous pasteurizers because they do their work continuously. They are arranged so that the milk to be pasteurized flows through the apparatus in an uninterrupted stream, being heated by passing in a thin layer over a metal surface on the opposite side of which is steam and being cooled in a similar manner in the same apparatus. Care should be taken not to allow the temperature to go so high that a disagreeable cooked flavour is produced.

SMALL SCALE PASTEURIZATION.

Milk can quite easily be pasteurized at home, if it has not already been done at the dairy. No elaborate or expensive equipment is necessary. Simply pour the milk in bottles so that they are nearly full and put the caps on, made of paper. Make a hole in the cap of one bottle and through this insert a small glass dairy thermometer. Set the bottles on a clean folded towel in a tin pail and around this pour warm water until it reaches nearly as high as the top of the bottles If the bottles are placed directly on the bottom of the pail, or if very hot water is poured around them, there is danger of breaking the glass. Place the pail over a fire and heat until the thermometer in the

bottle registers 145°F Remove from the fire and let the bottles stand in the water for 30 minutes, reheating if necessary to keep the temperature constant After 30 minutes pour in cold water to replace the hot water around the bottles and cool the milk as quickly as possible to 50°F Keep as cold as possible until used

If there is no thermometer at hand, milk may be pasteurized in the same way by heating the water around the bottles until a little below boiling point Let stand in this water for 40 minutes and then replace this by cold water as rapidly as possible

On the farm where milk is not bottled it can be pasteurized in glass jars The jars should first be thoroughly washed and sterilized An ice box is best for keeping milk.

STERILIZATION.

Sterilization of milk is another method by the dairymen to preserve milk, by subjecting it to sterilizing heat by means of steam; so as to kill all bacteria and their spores For the purpose a special apparatus is required. Fresh milk is taken and put into special sterilizing bottles, provided with spring stoppers lined with rubber washers, and then it is subjected to steam The bottles are previously cleaned and sterilized and then milk is put in, leaving

a quarter of the bottle empty. Then the stoppers are loosely put on and the closing caps are put in position after drawing out the closing rods Then the bottles are put into sterilizer, the lid is fixed and steam is gradually admitted The temperature is raised to 230° to 260°F and maintained for about half an hour. The lid of the sterilizer is opened after the steam is shut off and immediately the closing rods are pressed to fix the stoppers of the bottles Hot water is then admitted into the apparatus and after a time some slightly warm water so as to lower the temperature gradually in order to avoid cracking of bottles. When the bottles are cooled down to air temperature they are taken out and placed on stand horizontally and occasionally shaken in order to avoid the formation of a firm cream layer

Sterilization of milk is also effected by what is known as intermittent method, *i e*, by pasteurizing milk at intervals three or four times

PACKING FOR TRANSPORT.

Different types of containers are used in the milk trade at its different stages for assembling and handling milk Metal pots generally of brass, earthenware pots, galvanised iron drums with a capacity of 30 to 40 seers, buckets with bow handles for carrying on cycles, etc are in large use

Unless special care is taken in cleaning the containers for milk in a proper way each time before use, loss may take place due to souring of milk The life of milk can be lengthened if the milk cans which are seamless and permit of easy cleaning by hand, are used. Cylindrical vessels tapering at the top, with lids on, are deemed to be most satisfactory for the purpose

The milk for delivery should be sent in sanitary seamless, double-tinned milk cans This will fully ensure protection against rust, etc As soon as the cans are received back in the dairy, these should be immediately removed to the washing room There they will be washed and rinsed with filtered water and afterwards with hot water and sterilised with steam

Milk is sometimes sent in glass bottles, the mouths of which are closed and sealed The bottles are placed in carrier boxes divided into a number of compartments, each to receive one bottle The interspaces between the bottles may be suitably filled with grass The bottles should be washed as in the case of cans before repacking

CHAPTER V.

EQUIPMENTS AND MANIPULATIONS.

MILK and milk products are indispensable to the growth of the child and to the health of the adult. For them there is no substitute. Milk products thus play an extensive part in affecting public health and that these should be made under sanitary conditions is of great importance to the national welfare. Infant mortality, which is deplorably high in India, can be reduced to a minimum by scrupulous care during the processes of manufacture such that the important constituents of milk are not lost in the intermediate steps.

The industry requires a large number of equipments, including vacuum pans, cream separators, etc, etc Quality of the products depends upon the correct manipulation of the apparatus In the following pages are put together descriptions of the more important of the equipments; the rest are described in connection with the processes

CREAM SEPARATORS.

Separation of cream from the milk is the most important operation in the manufacture of milk products. The operation should be

carried out thoroughly. No portion of the cream should be allowed to go unseparated, and upon the degree to which the separation is conducted depends the success of the dairymen

Cream separators may broadly be classified under two headings:—

(1) Gravity cream separators.
(2) Creamery separators.

According to the first method separation of milk occurs under the action of gravity but the chief drawback of the method has been that the result obtained is far from satisfactory and much cream remains in the milk-serum

The more improved type of separators are the creamery separators in which the separation of the milk is effected by centrifugal motion imparted to the milk.

For home, use may be made of home churners but for large scale production these are of very little utility

GRAVITY CREAM SEPARATORS

What are known as *gravity creams* are produced by (1) Shallow pan system, (2) Deep-setting system or (3) Water-dilution or hydraulic system On the other hand *centrifugal creams* are produced by hand-separator or creamery-separator

In SHALLOW-PAN SYSTEM the milk is poured in pans to the depth of 2 or 4 inches as soon after milking as possible and is allowed to stand undisturbed for some hours Separation of cream from the milk serum takes place owing to the action of gravity. The creaming process is never complete by this method.

In DEEP-SETTING SYSTEM the milk is placed in cans 8 to 10 inches in diameter and about 20 inches deep, the cans are set in cold water and the milk is thus cooled to the temperature of cold water. The cream will rise in about 24 hrs This system is undoubtedly the best method of gravity creaming

In WATER-DILUTION SYSTEM, the separator consists simply of a tin can into which the milk is poured and then diluted with either hot or cold water to the extent of ⅓rd to ½ the volume of milk In a few hours the cream rises to the surface The explanation is this, When milk is diluted with water, the fat or cream rises much more rapidly and completely to the surface than it would in its undiluted form

CENTRIFUGAL CREAM SEPARATORS.

The centrifugal cream separator has now replaced the older gravity methods The principle underlying the two methods are the same The only difference is that in the centrifugal method the force which separates the cream

from the milk is generated by artificial methods, and acts in a horizontal direction, in the gravity system the force which separates the cream from the milk is only that which results from the difference in the specific gravity of the cream and the skimmed milk, and the force acts in a vertical direction The force generated in the separator is several hundred times greater than the natural force in the gravity method For this reason the cream separates almost instantaneously after the milk has entered the separator and is exposed to the centrifugal force

This method has therefore evidently many advantages over the older methods, of which the most important are·

(1) The cream is obtained fresh and of much better quality

(2) The thickness of the cream may be regulated to suit the purpose for which it is to be used

(3) Many impurities and undesirable germs are removed

(4) Fresh and unadulterated skim-milk is obtained which may be utilised for the manufacture of casein.

(5) Thorough separation of the butter fat

(6) A considerable saving in time, labour and space is effected

There are at present many different standard types of cream separators (Fig 1) in the market of various styles and sizes. On a small scale hand separators will be found suitable. On a large scale however, power separators (Fig 2) should be used.

The cream separator driven by power consists chiefly of the following parts:

(1) Supply can which contains the milk to be skimmed. This is connected by means of a milk faucet with the churner.

(2) Churning bowl provided with rotation discs. The bowl is provided with two spouts one for the outlet of the cream and other for the skim-milk.

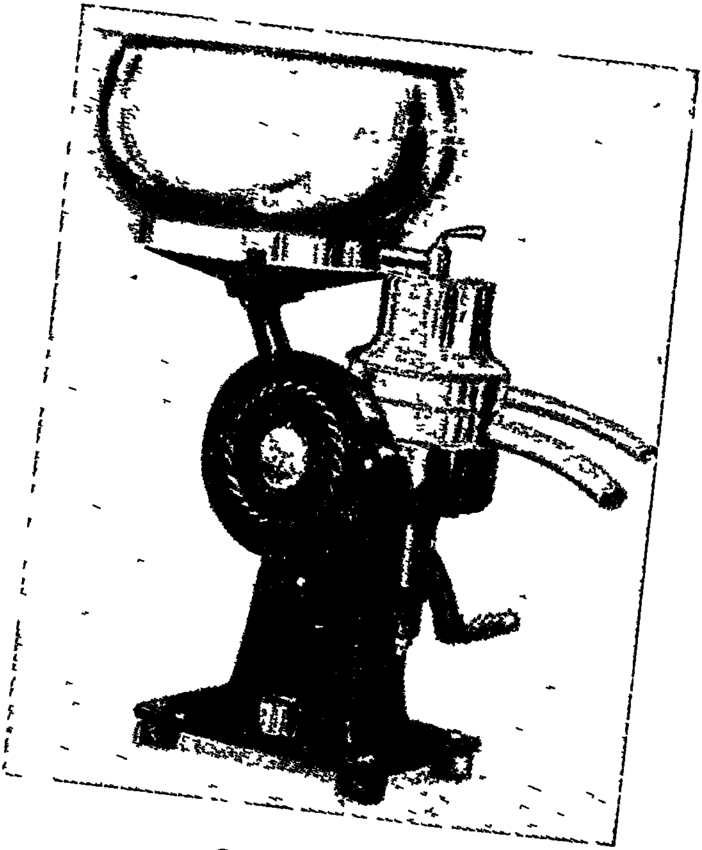
The supply can of the separator should be seamless so that no cream may get into the seams and spoil the next charge. In short it should be so shaped that it can be perfectly cleaned after churning

The bowl of the separator and separating discs should be so constructed that it can be easily cleaned and does not get rusted.

WORKING OF THE SEPARATOR

The bowl is imparted a rapid revolution by mechanical means. The milk enters the bowl at the top or bottom when revolving. As the milk enters and is exposed to the centrifugal force, it immediately begins to separate into different layers. The heaviest portions of

FIG 1

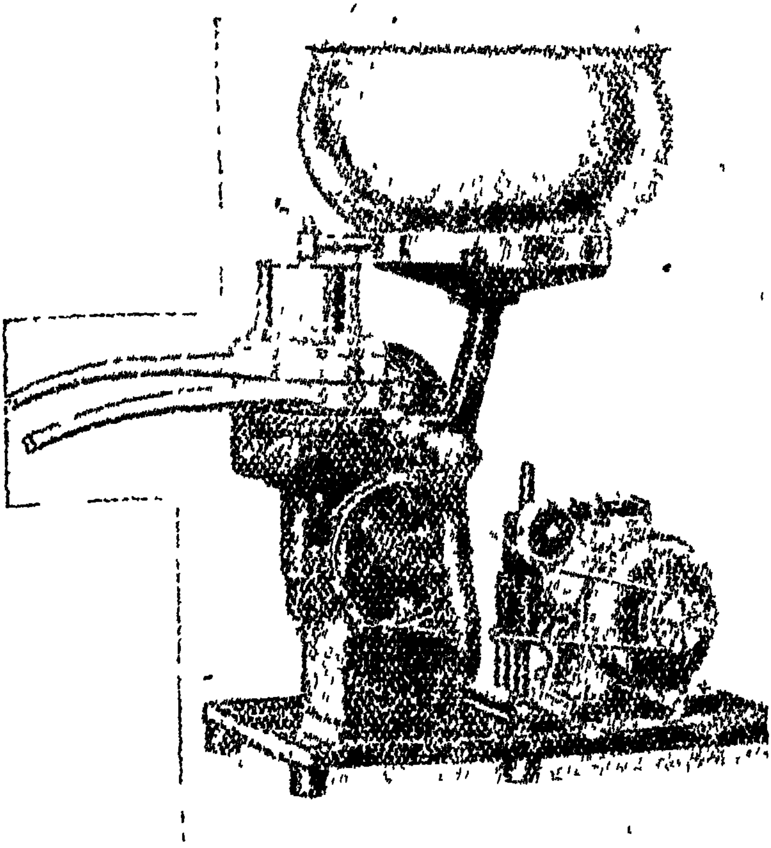


Cream Separator

M M P

[To face page 6(

FIG 2



Cream Separator, Power Driven

M M P

[*Reference page 60*

the milk and the precipitated albumin, oils, ash, filth, etc, are forced against the well of the bowl This is what is known as separator slime and is a solid and more or less gelatinous layer The second layer is the skim-milk Lastly the cream being the lightest is forced to the centre of the bowl There is, however, no distinct lines of demarcation between these layers The richest cream is nearest the centre of the bowl and gets thinner towards the outer portion. The cream-screw or outlet for the cream is, therefore, near the centre of the bowl while the skimmed milk is drawn away by an outlet at the edge

The importance of getting a cream separator of ample capacity cannot be emphasised too strongly For if the churning is not carried on as rapidly as it is proper, the milk will cool off during separation and this will naturally be followed by loss of butter fat in the skim-milk

The question of price often stands in the way of purchasing a big cream separator To buy a smaller one than warranted by the quantity of milk to be treated is a false economy which should be avoided as much as possible In fact a saving of twenty or thirty minutes twice a day will pay for a larger size many times over From practical experience the dairymen choose the size of the cream

separator such that whole milk can be separated in 15 to 20 minutes If one single machine is found quite inadequate to treat the whole amount of milk, the number of machines may be multiplied without making the size quite unhandy.

POINTS OF SUCCESS IN CREAM SEPARATING.

Thorough separation and the percentages of cream and skim-milk are influenced by centrifugal force or speed of the machine, uniformity of the speed, temperature of the milk, rate of inflow to the bowl, percentage of fat in the whole milk, physical condition of the milk, regulation of the cream or skim-milk screw The following points must be paid attention to for the efficient working of the separator.

Care should be taken in heating the milk previous to skimming The higher the temperature, the more fluid the milk becomes, and the easier the separation. Again all separators skim closed and not clog so easily when milk is heated previous to skimming By heating and stirring the milk in an open atmosphere, many undesirable odours and taints are got rid of. Moreover, the high heating of whole millk will destroy the germs in the resultant skimmed milk and cream

The milk should be in as good physical condition as possible, coagulated, slimy, or otherwise viscous milk separates with

difficulty. Milk containing impurities in suspension should be thoroughly strained previous to separation

When a separator is being overfed with milk there is a tendency for the machine to do less complete work It is possible to underfeed the separator, as well

The higher the speed, the more thorough is the separation It is essential that the machine should be brought up to speed gradually, and no milk allowed to flow through it until after it has acquired its full speed

An essential condition of a good separator is its smooth running

The efficiency of skimming depends to some extent upon the thickness of the cream skimmed

KEEPING MACHINE IN ORDER.

To keep the separator in good running order it requires to be carefully treated The machine should be always well oiled The bowl should be handled with great care When separation is completed, warm water should be passed through the machine whilst still running, which will facilitate cleansing operations Never stop a separator but allow it to slow down of its own accord, and always thoroughly clean all parts after use To prevent the bowls from rusting, either boil them in water or steam them after cleaning

If they are not used for some time, have them oiled. The contrivances on the inside of the bowl should also be handled with care so as not to injure them in any way.

FOREWARMING.

On many occasions as in butter making or in making condensed milk, manufacturers find it expedient to forewarm the milk before it is subjected to further processes. Special machines are called into requisition for the purpose. It essentially consists of copper kettles which are provided with a jacketting arrangement through which steam can be made to pass. Milk can be easily heated by steam passing through the jacket under pressure. To avoid the milk from burning, the heaters are provided with stirrers.

Continuous pasteurizers may also be employed for forewarming. The process has already been explained on page 52.

SUGAR WELL.

Another machine necessary in the dairy industry is the sugar well. This is a most ingenious method by which sugar may be incorporated with milk. It need not be mentioned that sugar to be thus added should be refined before use

Sugar wells are in fact tanks which are so constructed that small portions of hot milk are

allowed to flow at a time These are also provided with agitators which facilitate the mixing operation and with fine-mesh strainers at the top on which sugar is placed for mixing with milk

MILK DRYING MACHINES.

The most important machine in a dairy farm is that meant for drying or evaporating milk In making condensed milk, khoa, etc water contained in milk has got to be evaporated away, preferably at low temperature, which is likely to take great time At higher temperature, the evaporation is quicker but then the milk suffers from the chance of being charred and losing some of its good properties A vacuum pan has been found to be most effective In this machine milk is drawn into the pan continuously and only as fast as it evaporates due to reduced pressure in the pan The pan is provided with a series of coils through which steam is made to pass The pressure of steam can be increased or decreased gradually according to necessity

CANNING MACHINES.

In some cases canning machines are necessary during packing the articles in hermetically sealed vessels, exactly air-tight

Besides these, other appliances are used These are described in their proper places

CHAPTER VI

BUTTER-MAKING.

BUTTER-MAKING on a large scale is an important dairy industry There is a good margin of profit in it, if properly conducted. The Aligarh dairy-farmers have established themselves as pioneers in this line in India In big provincial cities, big towns and other places of importance there is a large consumption of table-butter. By far the major portion of the whole produce is consumed by the Europeans, the Indians generally preferring ghee which is nothing but clarified butter It is our purpose in this treatise to give a short discourse on the principle and practice of butter-making as it is practised in the creameries to-day It behoves us in these competitive days to follow the newest systems in vogue instead of drudging on with primitive methods.

CONSTITUENTS OF BUTTER.

As is well known butter is chiefly composed of milk fat which has been separated from most of the other constituents by the process of separation and churning The principal constituents of butter in addition to

the fat are water, salt, casein, and ash, whose percentage will vary with the methods of manufacture

VARIETIES.

Butter is generally known as creamery or country butter Creamery butter is made from mechanically separated and churned cream It is generally coloured and salted. The production of this is estimated to be about 50,000 lbs per day or about 8,150 tons per annum Outturn of butter is about 7 5 per cent of the milk

Country butter is made by churning sweet milk, curd or even cream Due to its acid flavour it is preferred for eating with chapaties In North Bihar, Bombay and Madras Presidency people purchase country butter for preparing ghee out of it at home .

Buffalo milk or cream is usually used for butter making

MILK FOR BUTTER

In India butter is made from two sources. viz, fresh or only scalded milk, or curdled milk (*dahi*) The former is more difficult to prepare than the latter but is more generally followed because the butter milk left after the separation of butter can be sold as *dahi* or *khir* In this chapter we deal with butter from fresh

milk The process of butter making from curds has been discussed in full in the chapter on Manufacture of Ghee, which follows later

PRINCIPLES OF BUTTER MAKING.

The essential points to be considered in butter making are:—The milking of the cows should be conducted cleanly and quietly The utensils for holding the cream should always be scrupulously clean. The milk is then perfectly cooled to free it of animal odour. The milk may be cooled by setting very large pails into a trough or box partly filled with very cold water and pouring the milk into these pails as fast as it is drawn from the cows Allow it to stand until of the required temperature and if necessary, renew the water.

The dairy room for setting milk should be cool and its temperature should never be more than 60° nor less than 40°C For butter making the milk fat is to be removed from the milk in the form of cream which should contain from about 30 per cent. to 40 per cent of fat So the milk is skimmed as soon as the first indications of getting thick from lopper are shown.

SKIMMING.

Skimming is done by means of the cream skimmer, which is a perforated, circular, and

slightly concave disc of sheet metal provided with a handle The disc must be carefully inserted down the shelving side of the lead, under the layer of cream, and lifted vertically being held absolutely flat and level meanwhile. The skim milk runs back through the perforations into the cream lead at the spot from which the cream has just been lifted, thus avoiding disturbance to the remainder, and the skimmed cream is poured into a cream pot held to receive it This operation is repeated till the whole surface of the milk is cleared of cream

The cream obtained has now to be mixed with the stock quantity in the ripening can, unless it happens to be churning day, in which case the cream taken that day commences a new stock The skim milk is to be utilised in making casein or cheese, as dealt later on

CENTRIFUGAL CREAMING.

In recent years, separation of cream is effected with the help of centrifugal cream separators The action of the centrifugal separator is to fling the cream present in the milk in the sides of the separator in the shortest possible time The milk instead of being allowed to throw up its cream naturally, is forced to do so by being whirled round at a great speed in an enclosed vessel. In such case

the lighter portion of the liquid remains in the centre of the vessel, and the heavier portion is flung to the outer walls of the container As a continuous supply of milk is coming in at the inlet the pressure forces the milk that has already been subjected to what is called "centrifugal force" and the outlets are so placed that from one flows the cream, and from the other the skimmed milk from which it has been separated

The force is applied by turning a handle fixed on the machine, the speed being increased manifold by the gearing which causes the bowl through which the milk passes to rotate at a speed of thousands of revolutions per minute The machine is now supplied with milk in regulated quantity till the quantity required to be separated has passed through, and been 'split-up' into cream and separated milk

RIPENING OF THE CREAM.

An important stage in the process of butter-making is the ripening of cream By cream-ripening is meant the treatment cream receives from the time it is put into the ripening-vat until it is put into the churn It comprises the chemical, biological and physical changes cream undergoes during the same time The main object of the process is to give the butter the flavour and aroma characteristic of butter of high quality It also

increases the ease and efficiency of churning and yields more complete results. Moreover, it increases the keeping quality of butter

The ripening or souring process chiefly consists of the development of lactic acid in the cream by bacteria which convert part of the milk-sugar present into lactic acid It is however found by experiment that the bacteria grow most rapidly at temperature of about 80° to 95°F Cream ripened at a lower temperature does not sour very rapidly Extreme and rapid changes of temperature should be avoided as much as possible Again the amount of starter which should be used with any given lot of cream will vary with the age of the cream, the percentage of fat, and the time during which the ripening process is to take place Good results can be obtained by adding starter to the extent of 50 p c of the cream to be ripened

It is to be noted that the fresher and sweeter the cream, the smaller the percentage of starter needed The starter should be of the best possible quality, as a poor starter is worse than none at all The starter is generally poured into the ripening vat, before the cream is separated Care should be taken to see that the starter has developed to the point at which the bacteria have their greatest activity As soon as the starter has been

brought into a proper condition, it is added to the separated cream. The cream should then be thoroughly stirred; otherwise mixing will not be uniform. When the constituents of cream are kept well mixed by stirring, the lactic acid checks the development of putrefactive germs which tend to accumulate on the surface The cream is thus ripened more evenly.

Cream in moderate quantities is best ripened in a wide-mouthed can, provided with a lip, by which the cream can be poured out conveniently

The temperature of the dairy should not be less than 70°F. because the temperature lower than this produces butter of bad flavour due to slow development of acid. The temperature above 70°F quickly ripens the cream. If it is not churned at the right time, strong flavours may result and also the texture of the butter suffers

It is usual to churn the cream twice weekly but this is not often enough in hot season, when cream ripens much more quickly.

By allowing the cream to ripen naturally however, there is a danger of producing butter having a poor keeping quality and flavour, owing to the action of harmful bacteria that may gain access to the milk either in the cow shed or when the cream is being ripened Further, there is no possibility of control by

which the growth of the desired bacteria can be encouraged

STIRRING CREAM FOR RIPENING.

The stirring of ripening cream is a very important part of the process. The acid forming organisms have no power of movement in themselves, they have a certain comparative weight, and they may be unevenly distributed in the cream at the first. This means that groups of lactic bacteria usually multiply to such an extent in so many separate spots that the amount of acid present might coagulate the casein in the cream This does occur in vessels of unstirred cream, so that when it comes to be mixed up previous to churning clots of jelly-like coagulum are encountered This sort of thing is fatal to the making of good butter, as bad flavours and curdy butter are the result

Moreover, the frequent and thorough stirring of cream distributes the lactic acid bacteria anew, after intervals of quietude during which they have worked undisturbed, breaks up the congested areas, introduces vigorous organisms to fresh supplies of food, and results in a uniform acidification of the whole mass with proper flavouring influences

No fresh cream should ever be mixed with the stock within 12 hours of churning, so

that the stock cream, being of even ripeness will yield the butter altogether.

After ripening the cream is stirred This makes the cream thinner When it readily runs off a smooth mixing stick, it is ready for churning.

STARTERS.

Starters are in much use in butter making. Hence all manufacturers should have a clear idea of what a starter is This is generally classed as either artificial or natural

Among the properties of a good starter may be mentioned that the more nearly pure it is, the better the results Moreover, the bacteria present in the starter should be in an active vigorous condition in order that they may develop rapidly in the cream and render it ripe for churning

NATURAL STARTERS are sour milk, butter-milk, etc This is prepared as follows Take a quart of new milk of known good quality and allow it to sour in a pure atmosphere Souring takes place in a day, provided the milk is kept at a suitable temperature Skim off the top and throw it away Stir the rest and mix with 2 gallons of separated milk which has been previously pasteurized by heating to a temperature of 185°F for twenty minutes Stir frequently this inoculated milk for the

first few hours, cover over with a muslin cloth, and then leave to sour The starter is ready for use next day

PURE CULTURE STARTERS are prepared either from pure laboratory or commercial cultures which are available either as a powder or in a liquid form. Butter-makers stir a commercial culture into pasteurized separated milk and keep at 80°F until the whole has soured They can add this to further quantities of pasteurised milk daily and thus have pure culture starter always near at hand

Either of the two artificial methods outlined above is preferable to natural cream-ripening

RIPENING WITH NATURAL STARTERS.

Both the natural and artificially prepared starters are used for ripening cream When natural starters are used, the cream is frequently stirred and allowed to sour or ripen of its own accord The raw cream is allowed to stand at a certain temperature until it is sour, then it is cooled to the churning temperature Thin cream ripens more quickly than that which is thick and rich, owing to its containing a larger quantity of sugar and less fat Sugar helps to promote and fat tends to check ripening Natural ripening may be assisted by the following easy means First raise the cream to a temperature of 90°F and

allow it to cool gradually. This promotes acidification in cold weather. Then add sour butter-milk obtained from a previous churning of good-flavoured butter at the rate of half to one pint to the gallon of cream. Keep near at 65°F until ripe, and then lower to the temperature at which it is to be churned

RIPENING WITH ARTIFICIAL STARTERS.

By artificial ripening is denoted ripening of raw cream to which sufficient starter has been added to control the kind of fermentation. This also ripens cream in which the germs have been destroyed by pasteurization, and to which a starter has been added in order to introduce the desirable ferments When starter is used, each lot of fresh cream should be pasteurised This should also be added as soon as possible

Pasteurized cream, ripened properly, yields a better form of butter The process of pasteurization consists in heating the cream on a continuous pasteurizer from 150° to 160°F and kept constant for 20 minutes By heating to such a temperature practically all of the germs, desirable and undesirable are destroyed with the exception of those that are present in the spore form This cream is immediately cooled to 70°-75°F. and the starter is added with stirring After this the whole is set aside to thicken at a cool place.

After the cream has been properly ripened it is subjected to the process of churning

CHURNING.

It is often the rule to strain the cream through a fine perforated strainer before it is transferred from the ripening vat to the churn All lumps and coarse impurities, if any, are removed thereby

By churning is understood the agitation of cream to such an extent as to bring the fat-globules together into masses of butter of such size as could be easily separated from the butter-milk

There are different ways of bringing about the agitation, and churns of different devices are employed for the purpose In its simplest form it consists of a shallow basin in which the milk is placed and a whisk is made to rotate on the surface of the milk by its handle being rubbed between the hands

The temperature of the cream is one of the most important factors in determining its churning The higher the temperature, the sooner the churning process will be completed On the contrary, cream at a low temperature becomes more viscous and the churning process is difficult The proper temperature should be determined by experience but the average desirable temperature under normal conditions varies between 50° to 65°F The cream from

buffalo milk can be churned at a higher temperature than that of the cow and yet produce equally firm butter, and hence one advantage claimed for churning mixture of cow and buffalo milk.

The amount of fat in the cream considerably affects its churnability. The richer the cream containing large fat globules, the sooner the churning will be completed whereas thin cream churns much more slowly

Again ripe cream is easily churned. For sweet cream is viscous whereas cream in an advanced stage of ripening is brittle. If thin cream is overripe, it should be strained well. However, the final composition of the butter is not affected by the ripeness or acidity of the cream

If the churn be too full, there is every chance for the cream to fall. Again, if the amount of cream be too small it may adhere to the side walls and do not receive any agitation Thus when the churn is about one-third full, the greatest degree of agitation is obtained and consequently a quicker churning follows

The churn should be such as to give the greatest degree of agitation to the particles of cream. The speed of the churn is also a consideration. If it be too rapid the cream will hold to the sides and receive no agitation Also, if it be too slow, the cream will be in the bottom

of the drum with little agitation Great skill is required in judging when the churning is complete If stopped too soon much may be lost in the butter milk, if too long protracted, the butter may become greasy

CHURNING PROCESS.

The last portion of cream is forced through the cloth by holding this with the corners together in one hand, while resting the lower portion containing the remains of the cream against the inner wall of the churn, and pressing the cream out through the bottom of the cloth with a cream " squeezee," a little strip of rubber set at right angles across a handle The churn should never be more than half-filled with cream, and preferably only one-third full

The lid of the churn is now securely fixed, and churning commenced slowly, by turning the handle steadily half a dozen turns when this must be pressed to allow for the escape of gas that is expelled from the cream

If it is not done, the cream will swell and froth and churning will be delayed After attending to this point several times in the first five minutes, churning may be continued at full speed, making 45 to 60 revolutions per minute

While the fat of butter is in the form of globules, it remains liquid at ordinary temperatures, owing to its very finely divided state, but violent movement and concussion cause

them to coalesce and solidify into fat grains so that in from 30 to 35 minutes from the start, the butter should "break," that is, the first solidification of the butter fat globules be indicated by a change in the character of the liquid being churned The cream no longer swishes round evenly, but moves more slowly This difference can be felt by the operator The sound also changes appreciably When this is apparent, the churning is stopped.

At the breaking stage, a small quantity of clean water is poured in at a temperature about 6 to 7 degrees below that of churning. This water will wash the grains adhering to the inside of the bed into the churn.

Churning is now resumed until, by the alteration in behaviour of the churn contents. the butter grains are at the right size.

The buttermilk is now allowed to run out and is strained through the hair sieve which catches any stray grains of butter. A measure of washing water is now poured in through a cloth strainer at a temperature 3 to 5 degrees cooler than at churning

In this washing, the butter is subjected to two or three rapid revolutions of the churn. and then withdrawn through the sieve If this water comes away milky to any considerable extent, a second quantity should be prepared and the operation repeated.

By this time the butter grains will have increased in size but should be firm, and reserve their singleness

If the butter is to be dry salted, it is taken out of the last washing by carefully scooping it into the hair sieve and placed in a heap on a table to drain of its water for the purpose of salting If the butter grains are to be brined, dissolve coarse salt—1 lb to each gallon of water—and strain it into the churn after the washing water has been drawn away

COLOUR IN BUTTER.

An artificial colour is used to supplement the natural colour of butter often deficient. It is used to maintain a uniform colour in the butter during the different seasons Ordinarily fresh and pure butter should have a natural rich yellow colour

The following are the requisites of an artificial colour —

(1) It should consist of some harmless vegetable material and be free from any taste and smell

(2) It should be strong and highly concentrated, easy of application and should colour the butter uniformly throughout

(3) It should have no reaction on the butter, nor injure its keeping quality.

Of vegetable butter-colours may be mentioned extracts of carrots, marigold, saffron and annatto. Carrot-juice is said to be the most healthful of all Aniline dyes should on no account be used as they are positively injurious to health.

Of the various substances used in colouring butter, carrots of the deep yellow variety have been found to give the natural colour and the most agreeable flavour.

Annatto, however, is principally used and with most satisfactory results. Butter coloured with pure annatto yields a rich, deep orange colour. If carrots are used, take two large-sized ones, clean them thoroughly and then with a knife scrape off the yellow exterior, leaving the white pith; soak the yellow part in boiling milk for ten or fifteen minutes. Strain boiling hot into the cream; this gives the cream the desired temperature, colours it nicely and adds to the sweetness of the butter As a rule, it is absolutely essential in the winter to colour butter to make it marketable.

IMPROVED COLOURING FOR BUTTER.

An improved colouring matter for butter—carotine—has been employed as a substitute for annatto, to which it is in every respect superior although somewhat more expensive. This carotine is the representative

in carrot of alizarine in madder and is obtained by slicing, drying and grinding the roots to a powder, exhausting the powder with sulphide of carbon and having removed the solvent, rapidly crystallizing out the carotine from the extract

To obtain the best results, the colour should be added to the cream before the churn has been started. Sometimes the butter is coloured by mixing the colour with the salt The salt is uniformly distributed and worked into the butter until it assumes a uniform colour But this method is not satisfactory. Butter colour is usually dissolved in oil and so readily mixes

STOPPING THE CHURN.

It is important that the churning process should be stopped at the right stage The two things to be especially controlled are the completeness of the churning and the removal of the butter-milk It is a general rule to stop the churning when the granules appear in the butter-milk and are somewhat larger than wheat-kernels, irregular and flaky in shape.

At this stage the butter-milk will have lost its creamy appearance and will appear bluish in colour instead Over-churning should be avoided as much as under-churning If the churning be continued until the butter granules are too large, the butter-milk will be incorpora-

ted in them, and cannot be removed by washing On the other hand when the butter is churned to small granules many of them will go through the strainer into the butter-milk, and thus will be a great loss.

When difficulty is experienced in the churning process it can easily be overcome by the proper ripening of the cream and modification of churning conditions

WASHING

As soon as the churning has been completed, the buttermilk should be drawn off from the bottom of the churn It should be strained through a strainer of fine mesh to collect even the small particles of butter The butter should then be washed with clean pure water

The chief object of washing butter is to remove as much butter-milk as possible The washing also modifies the hardness or softness of the butter-fat.

As soon as the butter-milk has been removed add an equal amount of water to the butter left Revolve the churn gently a few times and draw off this water Repeat the operation until the water drained off is quite clean

The temperature of wash water should be as nearly like that of the cream when churned as is consistent with the other conditions

Extreme and rapid changes in temperature should always be avoided as the texture of the butter-fat and the quality of the finished butter are injured thereby Ordinarily the water may vary from 50° to 60°F It should also be borne in mind that unless the butter is of very poor quality excessive washing is to be avoided Also, it is very important that the water used for washing should be as pure as possible: otherwise it should be properly filtered, purified and pasteurised

SALTING

While salt is not to be undervalued as a preserving agent, it must be remembered that too much of it destroys or overpowers the fine flavour and delicate aroma of the best butter Only so much salt is to be added as to remove the insipidity of butter Only salt of the best and purest variety should be used

The chief objects of salting are —

(1) to impart an agreeable flavour,

(2) to increase the keeping quality of butter,

(3) to facilitate the removal of butter milk

After the wash-water has been drawn off, the butter should be salted to meet the requirement of the trade Some consumers prefer a medium to high salt-content in butter, others

again, like butter which contains very little salt. The amount of salt thus varies from 0 upto 4 per cent Usually from half an ounce to one and a half ounces of salt per pound of butter-fat is suitable. Butter made from very good cream should not be salted too heavily On the other hand, butter made from a rather poor quality of cream may be salted correspondingly heavier.

The salt is usually applied by sifting it over the butter while it is in the granular form in the churn If salt of a high grade is used. it very quickly dissolves; and when the butter is subsequently worked, salt is incorporated into it Only the best quality of salt should be used as otherwise gritty butter will result and if the salt is not completely dissolved, it will give the butter a mottled appearance

The proper amount of salt to be added depends upon the following conditions —

(1) the amount and condition of moisture in the butter

(2) the amount of working the butter receives; and at what time the bulk of working is done

(3) the size of the butter granules and the hardness and softness of the butter

WORKING SALT.

The butter-milk should be nearly all worked out and the butter well-washed before

salting. Butter should stand but a short time after it is salted, before it is worked enough to remove all water and again it may be salted, if necessary. There should be sufficient salt left in the butter—this time to make strong brine of the little water that remains. It may then stand until the next day when it should be worked and packed On no account should butter be allowed to stand long before working The butter should not be underworked or overworked, for both of the causes spoil the butter. A great deal of judgment and discretion and somewhat of experience are requisite in order to determine when it has been worked just enough; the virtue of stopping in this is second only to that of doing There are some suggestions of practical nature which many prove valuable particularly to those having little experience:—

The butter should not be too warm when it is worked, nor should it be so cold as to make its working difficult. Immerse the ladle for a few minutes in boiling water and cool perfectly in cold water, then if the butter in the bowl is warm enough to admit of putting the ladle entirely through the whole mass without difficulty and dividing it up without crumbling and still hard enough to clean and smooth, not the slightest particle adhering to the ladle, then it is in the right condition to work.

Salt should be worked with careful and gentle, yet telling pressure and not by a series of indiscriminate stirrings and grindings against the sides of the bowl.

The butter should not be worked until it is perfectly dry. When ready to pack it should have a very slight moisture about it, a sort of insensible remains of the clear brine which has been working off

TEST FOR STANDARD TEXTURE

This working of butter incorporates the salt thoroughly in the butter ensuring the even distribution of the salt and brine This also brings the butter into a compact form giving it a close-textured firm body and expresses an excessive amount of butter milk or water, thereby removing these undesirable elements with a minimum injury to the grain The amount of working required to achieve these objects naturally depends upon the conditions and evidently affects the finished product There is a simple test for the standard texture of the finished product If the grains are large and cold very little working is required Working should be done quickly, but not roughly It should present the appearance of the granular structure of a piece of broken steel The percentage of moisture and of salt should be controlled There are wooden machines for working butter In carrying

on the operation attention should be paid to pressing, and not rubbing. The roller may be worked over the butter in forward and backward directions

PACKING OF BUTTER

Butter should be packed solid preferably in earthen wares with narrow mouths leaving no space for air It should completely fill the vessel leaving a flat surface It is common to put a cloth over the top and a layer of salt on the cloth This prevents decomposition of butter to a great extent Sometimes brine or salt water is added in place of dry salt The cover should then fit tight by leaving no room for air between it and butter

The next step is to print and pack the butter for the market When the butter is sufficiently dry and firm it may be made up It may be cut up and weighed into pounds and half-pounds as required There are different sizes, rolls, round prints, blocks, etc Fancy designs are sometimes met with The finished article should be wrapped in best vegetable parchment .In printing care should be taken to have the butter well pressed into the printer The packing of butter should be conducted under as favourable conditions as possible Before making use of the butter-ladles they should be scalded and then cooled off in cold water

MAKING-UP THE BUTTER.

The butter is made up into the desired shape either by pressing it into moulds or by wooden ladle. After this the butter is wrapped with vegetable parchment and stored in a cool place to allow it to harden.

POTTING.

Butter that is to be potted should be made from evenly ripened cream, which preferably has been pasteurized and ripened by means of a starter, and should be churned within 24 hours of being separated. Over-ripe cream should never be used. Cream that has stood for 3 or 4 days will be over-ripe and will not yield butter of good keeping-quality

FAULTS IN BUTTER AND THEIR CAUSE.

(1) *Churning Difficulties*—Whilst difficulties in churning may be experienced at all times of the year, they are more frequently encouraged in the winter months.

(2) *Sleepy Cream*—When the cream adheres to the inside of the churn and thus becomes unchurnable (usually after about 20-30 minutes of churning), it is said to have become "sleepy" This may often be overcome by reversing the churn two or three times and jerking sharply at each revolution Should this fail to break the cream, the top of the churn should be removed, the temperature

Taints may also be caused by an impure water supply or by bad general conditions.

(5) *Faulty Colour*—This defect is primarily due to the feeding of excessive quantities of cotton cake and roots which give a pale butter fat.

(6) *Leaky Butter*, i e., butter from which moisture exudes, is usually due to the use of too much salt, to insufficient working or to the use of washing-water at too low a temperature

(7) *Streaky Butter*—This defect is generally due to the butter having been washed insufficiently whilst in the grain, or to over-churning Great care should be exercised with regard to these points Further causes of streakiness are lack of care when dry salting and the use of impure salt

(8) *Mottled Butter*—This appearance is usually caused by over-ripening the cream, which should be stirred thoroughly twice daily to ensure an even ripening

RESTORING RANCID BUTTER

Rancid butter may be restored by melting it in a water bath with some fresh burnt and coarsely powdered animal charcoal which has been thoroughly freed from dust by sifting Then strain it through clean flannel A better and less troublesome method is to wash well the butter first with good new milk and next with cold spring water Butyric acid on the

presence of which rancidity depends, is freely soluble in fresh milk

PRESERVING FRESH BUTTER

The following is a typical process for preserving fresh butter :—

Melt butter in a well-glazed earthen pan, set in a water bath at a heat not exceeding 180°Fahr. and keep it heated, skimming it from time to time, until it becomes quite transparent, then pour off the clean portion into another vessel and cool it as quickly as possible, by placing the vessel in very cold water or ice In this state it may be preserved perfectly fresh for six or nine months, if placed in a close vessel and a cool place

Butter can also be preserved for a long time thus.—

Butter	150	lbs
Common salt	5	,,
Sugar	10	oz
Saltpetre	5	,,

Well mix together and pack away in tubes Open the tubes only when it is required for use, but take care not to use the butter within 3 or 4 weeks after keeping

COMPOSITION OF BUTTER

If properly prepared, butter will show the following percentage composition :—

Fat	82·97
Water	13·78
Proteids (curd)	·84
Milk-sugar	·39
Ash	·16
Salt	1·86

It will be seen from the above that the chief constituent is fat which varies from 82 to 90 per cent.

On an average a good sample of butter should contain 85 or 86 per cent. of fat, about 12 to 13 per cent of water, and ½ per cent of casein or albuminous matter.

It must be remembered, however, the quality of cream or milk from which the butter has been produced and the methods employed in the manufacture have more effect upon the quality of butter than has the composition.

TESTING BUTTER WITH ACETIC ACID.

The purity of butter-fat can be ascertained in various ways, most of which are highly technical. But the most valuable and simple test is the behaviour of butter fat with acetic acid. This is known under the name of *Valenta's* test. The method of carrying out this test according to *Chattaway, Pearmain,* and *Moor* follows.—

The butter-fat, melted and filtered at as low a temperature as possible, is further dried

by filtration through a dried filter paper. 27.5 grams of this fat are weighed into a stoppered test tube, and 3 c c of 99.5 per cent acetic acid added The tube is placed in a beaker of water which is gradually warmed until on shaking the tube, a clear solution is obtained; the temperature is carefully noted. The following figures represent the temperatures for butter fat and margarine respectively —

	Max	Min	Average
Butter fat	39.0	29 0	36 0
Margarine	97 0	94 0	95 0

In order to avoid any mistake always test the acetic acid first on a sample or samples of genuine butter fat. *Jean* prefers to determine the amount of acetic acid dissolved He weighs about 8 c c of the fat in a graduated test tube 1 cm in diameter, which is placed in water at 50°C Then he removes the excess of fat by means of a pipette until the fat measures 3 c c at 50°C, and adds 3 c c of glacial acetic acid (sp gr 1 0565) The contents are then warmed for a few minutes, and, after inserting a cork in the test tube, well shaken The tube is then immersed in the water at 50°C, and the amount of undissolved acetic acid determined

REFRACTOMETER TEST.

Another important test generally carried on for the determination of the purity of

butter fat is the observation of the refractive index by means of Refractometer For this purpose the fat, kept for some time at 20°C, is spread out on a watch glass, and covered by a piece of filter-paper; the fat is absorbed by the paper, and a clear grease spot forms in the centre The grease spot is applied to the edge of the Nicol's prism to which it readily adheres, the apparatus is closed, and the angle estimated

The following are the refractive indices of pure butter fat and certain other oils which may enter into the composition of butter substitutes —

Butter fat at	25°C	1 4587	to	1 4615
„ „ „	38°C	1 4540	„	1 4569
Coconut oil at	38°C	1 4500	„	1 4515
Lard at	38°C	1.4490	„	1 4505
Cotton-seed oil at	38°C	1 4660	„	1 4680
Suet at	38°C	1 4605	„	1 4620
Margarine at	20°C	1 4698		

CHAPTER VII.

GHEE.

AMONG the milk products in use in India ghee occupies a very high position in the daily diet of the population Its importance has been emphasised even in the ancient Vedic texts Carbohydrates, albuminoids and fats are three types of food, absolutely essential for uniform and proportionate development of the human body. A vegetarian can get a supply of the requisite quantity of carbohydrates and albuminoids from the vegetables but so far as the supply of fat is concerned there is no other source of material except pure ghee and vegetable oil

In cold countries as Europe, ghee is not known except in some warm zones of Europe. Butter and margarine are usually the articles which serve as its substitutes Indian's preference for ghee can mainly be ascribed to the fact that ghee not only keeps better than butter, but, to them at least, it has got better taste and flavour.

The Indian dairy industry may well add crores to its annual income if the wasteful methods now in use of manufacturing ghee are abandoned in favour of the cream separator

method or the method of making ghee direct from cream. The annual value of the ghee produced and sold in India is nearly Rs. 100 crores This is one-third of the total value of milk and milk products and exceeds the total value of solid and liquid milk derivatives manufactured in India by about Rs. 15 crores. Of the total annual production of about 70 crore maunds of liquid milk, nearly 36 crore maunds are used in ghee making, giving an annual output of 23,000,000 maunds of ghee.

VARIETIES.

In India, ghee is chiefly made from the milk of cows and buffaloes and only in rare cases from those of the animals such as goats and sheep. From ancient medical point of view ghee from cow milk is superior to that from buffalo milk. Ghee from goat milk is much inferior owing to the disagreeable odour it possesses while that of sheep milk is often spoken of as superior to buffalo milk Old cow ghee is much valued in medicine, and ghee a hundred years old is often heard of. The major part of the ghee made in India is derived from buffalo milk and the industry is mostly located in the United Provinces, Bengal, Rajputana, Central India and the Punjab.

It is estimated by manufacturers that one quart of buffalo milk yields about 3 oz. of ghee while the same quantity of cow milk may only

afford about half that quantity, or with extra fine qualities, three-quarters of the ghee mentioned

GHEE BOILING.

Properly speaking, ghee is nothing but clarified butter, i.e., butter from which casein, curd and water have been driven out. It is mainly obtained by heating butter until it loses the greater part of the moisture.

In ghee making, great care should be paid to the boiling operation Too much heating is said to cause the ghee to assume an acid taste, while imperfect heating renders it liable to putrefaction Great skill is thus required, but the ghee sold in the market has usually been undercooked owing to the loss in weight which takes place when fully cooked Butter loses about 25 per cent in the process of clarification. The yield of ghee from the butter of the buffalo is higher than from that of the cow

TWO SOURCES OF BUTTER FOR GHEE.

Now two methods are usually followed in India for deriving the butter for ghee. One consists in collecting the cream after fore-warming the milk and then allowing it to cool. It is then usual to subject the cream to ripening, churning and washing as described under Butter Making Amateurs sometimes bray the

ripened cream on a muller before the churning operation is begun.

The second method consists in first placing the milk in a clay or metal pot and heating for 1 to 3 hours, depending on the quantity, until it thickens through loss of moisture. When the desired thickness is obtained, it is cooled. At this stage it is soured by the addition of curdled boiled milk (dahi) and allowed to stand for 12 hours. In place of curd, a vegetable or animal rennet is sometimes used for souring purposes The souring of the milk precipitates the casein and sugar of milk, in the watery layer below the soured curd The curd is separated and placed in a churn, which is revolved until the butter has formed, or is churned in a vessel by means of a split bamboo, jerked upwards and downwards, or alternatively revolved in the soured milk After about half an hour, a little warm water is added, and the churning continued for another half an hour, when the butter forms The butter is then roughly collected, and is heated in warm water to separate out the remaining curd, which is entangled in it In order to collect a quantity sufficient for making ghee the butter is often kept for 2 or 3 days

PREPARATION OF GHEE.

When a sufficient quantity of butter has been collected, it is heated at a gentle heat until

it is freed of all water. This stage is noticed by total stoppage of the sound of boiling water. The ghee pot should then be removed from the fire and allowed to cool. Strong heat may cause a partial charring and consequent bad smell of the ghee. While the ghee is still liquid and warm, it should be strained through a piece of moist clean linen and then kept covered in tinned pots or earthenware in a cool place.

Ghee made from fresh butter keeps well for a long time while that made from spoiled butter is spoiled in a very short time and smells bad Market ghee always contains a small amount of water or butter milk, in the presence of which some fats are readily decomposed and the ghee turns rancid In order to prevent this, the best way is to purify it as explained on p 104

DEFECTS OF THE PROCESS

It is quite a common thing in this country, to allow the butter and remaining curd to be collected from day to day in an earthenware pot, until there is sufficient quantity, say 10 to 15 seers to make a saleable quantity of ghee During this period of "collecting", the product is not properly covered but exposed to all kinds of dust and germs, and the acid value of the resulting ghee rises abnormally, owing to the presence of the acid curd. In general, the acid value of ghee as sold in this country may range

between 5 and 15, whereas, ghee prepared under proper conditions would have an acid value under 1. The methods of preparation are extremely crude, and the conditions are such that there is but little doubt that much disease prevalent in India could be traced to the processes and conditions under which the various milk products are manufactured It is not improbable, owing to the various heat treatments in the process of manufacture, that the majority of the valuable vitamins contained in milk and milk products, are entirely destroyed On the other hand, it is possible that many disease germs are also destroyed There is no doubt that ghee could be prepared under the hygienic conditions similar to those under which butter and milk products are prepared in Europe, Ghee is nothing more than butter which has been carefully melted and free from curd

IMPROVED METHOD.

According to Mr J A Hare Duke of H B. Technological Institute, Cawnpore the existing wasteful and harmful methods of ghee manufacture can be improved to a large extent The methods suggested by him are as follows.—

When the churning is completed, the ghee should be carefully separated and placed in a tin-coated vessel of iron, copper or brass,

having a conical bottom with a tinned brass stop-cock

Prior to placing the ghee in this vessel, the cock should be closed, and the vessel filled half full of water which has been boiled When the ghee is placed in water it should be sufficiently hot so as to just permit the hand touching it without being burned The ghee should be stirred gently with a clean tinned instrument, and after 5 minutes the water should be run off, and more added The ghee should again be washed to remove all traces of curd, and the washing should be continued with fresh water, until the water comes away clean The ghee should remain in this vessel so as to settle out the few remaining drops of water In order to prevent it getting cool, the whole vessel should be placed in a second vessel containing hot water

Now to obtain proper crystallisation or grain, the separated pure ghee as obtained above should be placed in another vessel tinned inside This vessel must be exceedingly clean and dry It is placed in a second vessel containing cold water. The melted ghee should be slowly stirred with a clean tinned instrument, until the ghee becomes cloudy and shows a sign of thickening When all traces of clear or liquid oily ghee are no longer to be seen, the vessel may be removed from the water, the stir-

ring may be stopped, and the ghee allowed to solidify.

PREVENTING RANCIDITY IN GHEE.

The bad, strong taste which so often develops in ghee is chiefly due to bad separation of the curd, or dahi, from the ghee.

This curd is naturally a very acid substance; it decomposes and gives a bad flavour to the ghee. The greatest care should be taken to separate this rapidly from the ghee, and those portions which cannot be separated should be washed out with warm water. Very great care should be taken after the washing process is completed, to separate out the last drop of water. This can be done by keeping the ghee warm during the process of settling, and this should take 3 to 4 hours The moisture will gradually settle down and can be carefully run off through the stop-cock at the bottom of the conical shaped vessel

PURIFYING GHEE.

Take the ghee in a deep iron vessel along with twice its weight of water. The vessel is then gradually heated and the ghee is stirred constantly with a ladle.

By this process, all the organic matter derived from the milk is gradually taken up by the water. The stirring is continued till the water begins to boil. The mixture should be

allowed to cool to a certain extent and the ghee collects as a clear layer at the top. It is taken out by means of a shallow vessel or ladle and poured through a thick linen filter when the remaining impurities are removed. The last portion of the impurities which cannot be separated from water is again taken with a fresh charge.

ADULTERATION.

Adulteration of ghee has now become a serious menace to public health Not only are the natural oils and fats being used with impunity, but even fats obtained from diseased animals are fraudulently mixed with ghee.

The following is a list of the animal and vegetable oils and fats generally employed for adulterating ghee:—

(a) Animal fats, lard and tallow

(b) Vegetable fats and oils, coconut oil, cotton seed oil, cotton seed stearine, sesame oil, groundnut oil. soya bean oil, mahuwa oil, poppy seed oil, safflower oil and illipe oil

(c) Hydrogenated products

From scientific point of view no serious objections can be raised against the substitution of the cheaper animal and vegetable products for the more expensive ones, so long as these substitutes are sold under their proper names and are not used for fraudulent purpose In European countries such oils and

fats are refined and sold under respective trade names, so that the purchaser knows exactly what he is paying for. But in India adulteration plays rampant in all parts of the country The result has been that it is difficult to get pure ghee from the market. Competition is also driving away good ghee out of the market Some sort of legislation is necessary to check this evil.

TESTS FOR DETECTING ADULTERATION.

There are good many tests for detecting adulteration A few simple tests as recommended by Prof R. B Seth are given below These have been tried and found to give fairly satisfactory results when pure ghee is adulterated with common impurities like oils, vegetable ghee, tallow, lard, or wax

Ghee is largely adulterated with oils To detect their presence one should note that ghee differs essentially in composition from all other oils and fats excepting coconut and palm kernel oil in having a large percentage of steam-volatile and water-soluble fatty acids And in the case of coconut and palm kernel oils (which are rich in steam-volatile and water-soluble acids like ghee) there is marked absence of butyric glycerides which are most prominently present in ghee It is therefore this important and least variable constituent which differen-

tiates ghee from the coconut type of oils on the one hand and of the oils and fats on the other

Nitric Acid Test

This test is based on the fact that the nitro-compounds of fatty acids and their esters, formed by the action of nitric acid on pure ghee, are colourless, whereas those with vegetable ghee, tallow or wax are coloured

Boil some water in a small vessel Take a little (about 3 c c or one-eighth full of tube) of the given specimen of ghee in a test-tube and place it in the boiling water to melt it Now pour 2 or 3 drops of pure and colourless nitric acid, and put the tube again in the boiling water for a few minutes If the ghee is pure, its colour remains practically unchanged If not, the liquid turns yellow, orange, or reddish-brown, depending upon the nature and amount of impurity. The vegetable ghee turns deep-yellow, tallow or lard orange; wax reddish-yellow An intermediate colour is obtained when ghee is mixed with any of the above impurities On standing the coloured liquid obtained solidifies more quickly in the case of impure ghee than in the case of pure ghee

Soda-ash Test

This test is based on the fact that pure ghee is very slightly saponified by sodium carbonate, while vegetable ghee or vegetable oil

in admixture with ghee is readily saponified by it and forms soap.

Dissolve some soda-ash in three times the quantity of hot water. Melt a little of the given sample of ghee in a test-tube as before, and pour about the same quantity of the soda-ash solution to it. Shake well and place the tube in boiling water for a few minutes. If the ghee is pure, the liquid becomes turbid due to fatty globules, and practically no soap is formed On standing, two separate layers are formed; the upper transparent layer consisting of molten ghee and lower one of the soda-ash slution. If, however, the ghee is adulterated with vegetable ghee soap is formed by the combination of sodium carbonate with vegetable ghee On standing the soap separates out in the form of a white (or yellow) layer, the lower layer consisting of excess of the soda-ash solution The amount of the soap formed depends upon the quantity of vegetable ghee present

This method can conveniently be employed for the quantitative estimation of the vegetable ghee present in pure ghee and offers an easy means of detecting adulteration

PACKING.

Formerly all ghee was packed in earthen jars (matkas), or for transport to a distance in leathern cases (kuppas), but in recent years

tin canisters, or specially made canisters having a capacity of $2\frac{1}{2}$ seers, 5 seers, 10 seers and 20 seers have been employed.

GHEE FROM SEPARATED CREAM.

During the process of making ghee by the present method no less than 325 million mds. of butter-milk or lassi is set free in India. This enormous quantity fetches no monetary value to the manufacturers and in the large ghee producing areas, this goes to waste The cream separator method of making butter and ghee, yields both cream and separated milk as has been explained earlier under Butter Making and would thus add enormously to the income of the producers The cream could be converted into ghee and the separated milk used either for liquid consumption or for conversion into suitable and profitable diverse liquid and solid derivatives which would be more remunerative to the manufacturer Apart from facilitating profitable utilisation of separated milk, this new method helps controlled manufacture, yields a higher output of ghee of uniform and good quality and saves much time and labour.

The equipments required as already stated consist of centrifugal cream separators and appliances for collecting and heating cream and stirring and straining ghee. There is no

souring of milk and no churning of curd into butter. If the cream separator is properly adjusted and handled, cream containing 50 to 60 per cent of butter fat is easily obtained. A small holder could separate his daily quantities of milk into cream for three or four days until the product obtained is sufficient for clarifying. A portion of the separated milk could be consumed or fermented to serve as 'lassi' and the remainder sold

At the Imperial Dairy Institute, Bangalore, the cream was separated from fresh cow's milk by means of a hand cream separator. The milk was heated to 150°F and then centrifuged The hot cream was thereafter diluted with the hot separated milk and re-centrifuged The hot cream was thereafter richer cream. In this manner cream containing 74 per cent. butter fat was obtained and toned with the hot separated milk to different butter fat contents

Experiments, so far conducted, have shown that butter fat and water contents do not much affect the quality of ghee obtained and that it is possible to obtain ghee of good quality from fresh cream. The new method has also been found to give 18 per cent more yield than the "desi" or indigenous method of making ghee from butter and also to enhance the keeping quality of the product

LATEST DEVELOPMENTS.

A popular method of manufacturing ghee by curdling of milk by natural souring has been found at times, to give to the ghee produced an undesirable flavour To prevent this citric acid may be used for the coagulation of fresh milk The product is churned and ghee is obtained by heating the butter. The ghee is much superior in quality and quantity to the ghee made by country method.

Observations show that there is a relationship between the rate of cooling and the size of ghee granules It is found that the temperature at which ghee is made has an influence on the size of the grains, the higher the temperature the larger is the size of the grains on cooling It is further observed that repeated heating destroys the power of granulation, that cows' ghee develops smaller grains than buffaloes' ghee, and that the ideal temperature for making ghee with good aroma, colour and grains is 120°C

Typical ghee of good quality should not contain more than 2 5 per cent oleic acid and 1 0 per cent moisture

The butyro-refractometer reading should vary from 40 0 to 42 5 and the saponification value 220 to 226

CHAPTER VIII.

CONDENSED MILK.

CONDENSED milk is cows' fresh milk from which a considerable portion of the water has been evaporated and to which sucrose may or may not have been added. The removal of a large percentage of water greatly reduces the cost of transport; the addition of sugar or sterilisation of the finished product increases its keeping qualities to several months

A portion of the condensed milk on the market is made from the chief bye-products of milk, skim milk and butter milk

VARIETIES.

There are chiefly two classes of condensed milk, namely sweetened and unsweetened. Both reach the market in hermetically sealed tin cans intended for direct consumption.

Condensed milk is sold under specific trade names according to process of manufacture and composition Thus sweetened condensed milk is condensed milk containing added sucrose.

Plain condensed milk is condensed milk containing sucrose and which reaches the market unsterilized.

Skimmed condensed milk is condensed skim milk containing added sucrose

Unsweetened or evaporated milk is condensed milk to which no sucrose has been added and which has been sterilized in hermetically sealed cases

Plain condensed milk contains sucrose and which reaches the market unsterilized.

The process practically consists in evaporating the greater portion of water present in the milk and in special cases in adding sugar to enhance the preservative quality of the product

PRINCIPLE OF MANUFACTURE

Milk, as received from the dairy, is run into square vats some four or five feet above the level of the bath tubs which are set with a coil of steam pipe attached to the bottom and are nearly filled with water. In this bath are set cans with a capacity of about 40 quarts The milk is run into these cans from the receiving vats and the temperature of the bath is raised to 150° to 175°F It is then transferred into a specially constructed heating apparatus having jacketted steam bottoms and is there heated to boiling It is next run into the vacuum pan into which the work of evaporation goes on at a much lower temperature If the milk is to be preserved plain, without the addition of sugar, it is evaporated

to a quarter of its volume, and as soon as the vacuum is broken the temperature is raised to 200°F If sugar is to be added, the hot milk from the vacuum pan is run into pans containing the requisite quantity of refined sugar.

EQUIPMENTS.

Manufacture of condensed milk of superior variety demands the use of a large number of machines, of which the most important are forewarmer, super-heater, sugar-mixer, vacuum pans, homogeniser, cooling coils and filling machines A description of the machines has been given in their places

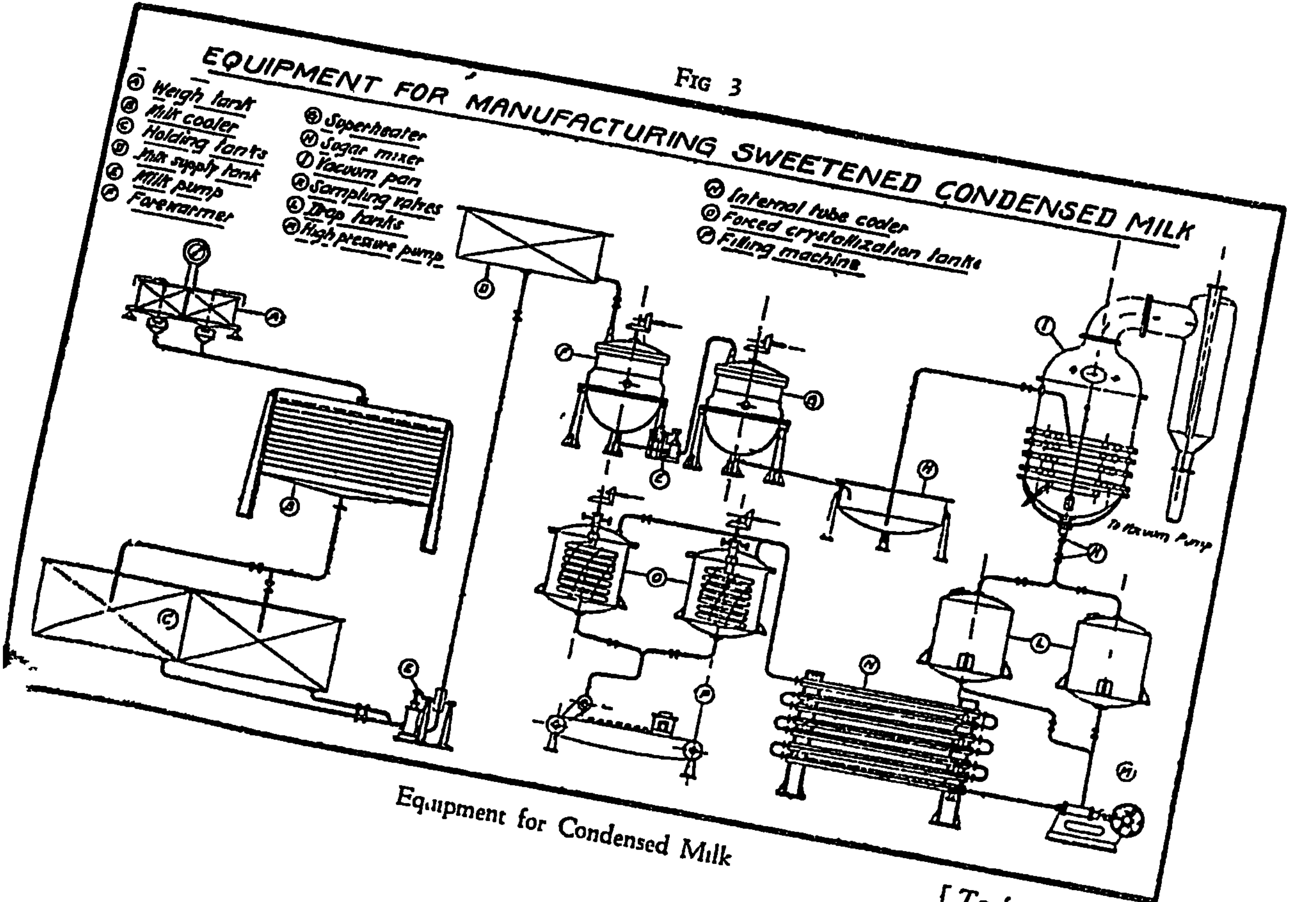
The equipments required for the flow of the milk from weighing tanks on milk receiving platform to filling machine for finished product are diagrammatically illustrated in the accompanying diagram (Fig. 3).

AN OUTLINE OF THE PROCESS.

From weighing tanks (A) the fluid milk flows over a cooler (B) into holding tanks (C) where it is standardised to the desired proportion of fat and other solids It may be found between the weighing tanks and cooler.

From the holding tanks the standardised milk is pumped by pump (E) into milk supply tank (D) from which it flows by gravity through forewarmer (F) and super-heater

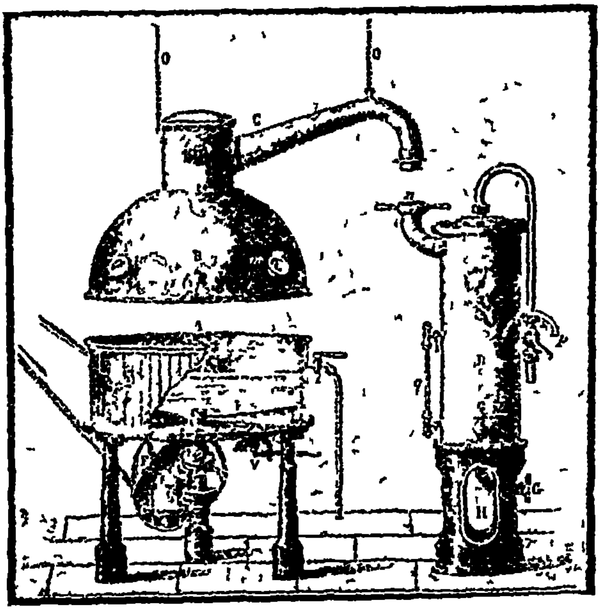
FIG 3



Equipment for Condensed Milk

[To face page 114

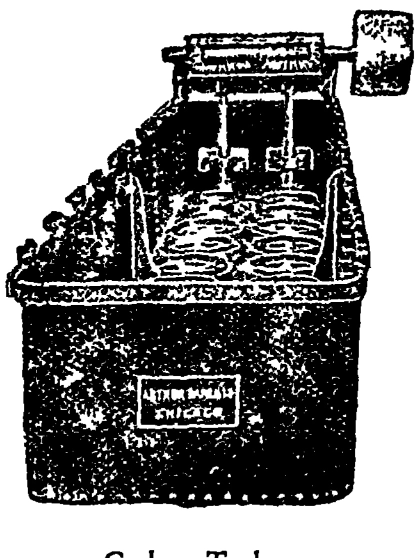
FIG. 4



Vacuum Pan

[Reference page 119

FIG. 5.



Cooling Tank

[Reference page 123

(G) into sugar mixer (H) From here the milk enters the vacuum pan (I) and the condensed milk drops through sampling valves (K) into drop tanks (L) where it may be standardised for total solids. These drop tanks might conveniently rest on scales so as to facilitate the determination of the exact weight of each batch.

The standardised condensed milk is then forced by pressure pump (M) through cooling coils (N). The cooling coils are either of the internal tube cooler type, similar to an ammonia condenser, or they may be submerged in a tank through which the cooling water circulates The cooling coils discharge the condensed milk into the forced-crystallisation tanks (O) and from here it drops into the filling machine (P) where the tins are filled and sealed

Processes of making sweetened condensed milk, plain condensed milk and skimmed condensed milk are given one by one

SWEETENED CONDENSED MILK.

In commencing to manufacture sweetened milk, the fluid milk as received in the factory is "dumped" through milk strainers into the weighing tanks placed on scales Here milk from each source of collection is sampled for fat test, weighed and filtered over a cooler and run into holding tanks These tanks as

soon as filled, are sampled, the percentages of fat and solids not fat are determined and the milk is standardised to the desired proportion of fat to solids These tests are of great value to the manufacturers and are materially helpful in calculating the amount of sucrose to be added in order to obtain the desired ratio of sucrose to total milk solids. After condensing the finished product is finally standardised to the desired percentage of total solids by the addition of water, if necessary.

When the desired amount of milk has been collecting in the holding tanks and tested for fat and solids, it is necessary to standardise to the correct ratio by adding the cream or skimmed milk according as there is deficiency or surplus in fat.

Forewarming the Milk

The first step in the process is to heat the milk to near the boiling point There are several reasons of which the most important are first to destroy most of the bacteria, yeast, moulds and other organised and unorganised ferments present in fresh milk; secondly, to facilitate the solution of the sucrose, which is essential, and lastly to prevent the milk from burning on to the heating surface in the vacuum pan This forewarming process also has a direct influence on,- and in a large

measure controls, the tendency of the condensed milk to thicken with age.

This forewarming of large volumes of milk to temperature nearing its boiling point (190° to 210°F) requires careful consideration. A variety of methods and numerous different types of machines (p. 64) are used for this purpose Some employ large copper kettles in which the milk is heated by turning steam direct into the milk Others use jacketed copper kettles equipped with a revolving agitator The milk is heated by turning steam under pressure into the jacket and the burning of the milk is prevented by keeping the milk in constant motion In this case the milk is usually heated to about 170°F by the jacket and from thereon the temperature is raised to that desired, by turning steam directly into the hot milk Still others are heating the milk by means of large continuous pasteurizers in which case hot water or steam serves as the heating medium The milk passes in a thin layer between two water-heated surfaces, one of which is revolving

Addition of Sugar

When the standardised milk has been forewarmed, the calculated amount of refined sugar is added About 19 to 20 pounds of sugar to every 100 pounds of fluid milk is quite sufficient European condenseries have

as a whole preserved a higher standard of milk solids to cane sugar and they add about 15 to 16 pounds of sugar to each 100 pounds of fluid milk Need it be mentioned that sugar to be added should be of the refined variety

It is not desirable to use excessive sucrose in condensed milk because condensed milk serves as a substitute for fresh milk The more sucrose it contains, the greater is the difference in composition and properties between the condensed milk and the fresh milk Sucrose is not readily digested as the other ingredients of milk; therefore, the presence of excessive amounts of cane sugar in condensed milk tends to reduce its digestibility and its wholesomeness as a food

Mixing the Sugar

The sugar is added to the hot milk before the latter enters the vacuum pan. A separate tank is provided for this purpose Small portions of the hot milk are allowed to flow into this tank To these the sugar is added This tank is known as the sugar well It is usually equipped with a mechanical reversible stirrer, moving to and fro on an eccentric, to facilitate the solution of the sugar The milk from the heater and from the sugar well runs into a tank sunk in the floor, called the ground well, from which the mixed sweetened milk is drawn into the

vacuum pan In some factories the sugar well and ground well are one and the same tank, into which the milk runs directly from the heater In this case it is advisable to set a wire mesh strainer over the sugar well The sugar is placed into this strainer, a little at a time; the hot milk from the heater passing into and through the strainer dissolves the sugar

This hot milk containing the added sucrose is now ready for the condensing process in the vacuum pan

Condensing the Milk

Before actually drawing the milk into the vacuum pan (Fig 4) it should be thoroughly rinsed with water, then heated by steam until the temperature rises to about 180°F or above Then the manhole cover is put in place, all the air valves are closed, water is turned into the condenser and the vacuum pump started When the vacuum gauge shows about 29 inches of vacuum, the pan is ready for the milk

As soon as this point is reached the valve of the milk pipe leading to the pan is opened to admit milk into the pan The milk enters the pan automatically as a result of the reduced pressure in the pan When the milk covers the jacket, steam is gradually turned into the jacket

As each coil becomes submerged in the milk, it is charged with steam. At no time should steam be turned on jacket or coils when they are not completely covered with milk, as such operation would cause the milk to stick to and burn on the heating surface, thereby impregnating the milk with a disagreeable burnt flavour.

At the start the steam pressure on jacket and coils should be held low, so as to avoid the danger of cooking on, owing to the presence of considerable quantity of air coming along with fresh milk. As this air is removed and the milk "settles down" to uniform boiling, the steam pressure may be gradually increased until it reaches the maximum which varies from 5 to 10 pounds of saturated steam pressure suitable for use. Because of the sensitiveness of milk to heat, it is preferable to use as low steam pressure as possible, consistent with maximum rapidity of evaporation

The fluid milk contains considerable quantities of air producing foam So if it is drawn into the pan very quickly, there is danger of heavy entrainment losses This is best avoided either by opening a part of the milk in the pan very closely and admitting a small amount of air through the vacuum brake whenever the milk rises dangerously high The difficulty occurs only at the start. The air is removed

quickly and the vacuum returns to normal condition In the earlier stages of the operation, evaporation goes on very rapidly, this gradually diminishes as the process prolongs and is lowest towards the end of the process.

When sufficient milk enters the pan so as to completely cover the jacket and coils, the milk in-take should be reduced and regulated according to the rate of evaporation. The milk is drawn into the pan continuously, but only as fast as it evaporates It should be kept as much as possible at a constant level and this level is preferably as low as is consistent with complete covering of the uppermost coil Carrying the milk at a very high level makes uniform operation difficult, because it tends to reduce the speed of evaporation.

At the temperature at which the milk is in the pan, condensation is nearly completed, and from ten to twenty minutes' further boiling usually gives the milk the desired density Towards the end of the process the steam pressure in jacket and coils should be gradually reduced When the milk approaches the desired density, it is comparatively heavy and viscous, it boils less vigorously and its movement is more sluggish Each particle of milk is exposed to the heating surface for a longer time In the case of excessive steam pressure, its quality is greatly altered If the batch is

small so that the level of the milk drops below some of the coils, steam to each exposed coil becomes visible. It is advisable also to permit the temperature to drop when the end point approaches, so as to minimise the tendency of this viscous product to superheat.

Finishing Operation.

When the boiling milk in the vacuum pan approaches the desired degree of concentration, sample of milk is taken out and tested for density. There are various indications reminding the expert pan operator that the milk in the retort is nearly done, viz., time consumed for condensing, time elapsed since all the milk has been drawn up, amount of condensed milk left in the pan and, most of all, the appearance and behaviour of the boiling milk itself

Of the above conditions the best way of understanding the desired consistence of the condensed milk is to test its density with a Beaume's hydrometer by floating it freely in the sample. This way of testing is mainly carried on in most factories

Drawing off the Condensed Milk.

As soon as the evaporation is completed, the steam is shut off from the jacket and coils, the water valve is closed, the vacuum pump stopped and the vacuum pump started again in order to remove the hot air over the milk The milk is drawn into cooling vats The

condensed milk should be drawn from the pan as rapidly as possible to prevent its superheating while in the pan. When all the milk has been drawn off, the pan is thoroughly cleaned with pure water so as to make it ready for the next batch

Cooling

This is a most important phase of the manufacture of sweetened condensed milk Not only is it necessary to cool the hot milk promptly when it comes from the pan to avoid superheating and thickening of the product, but on the process or manner of cooling depends largely the smoothness of its texture due to crystallisation of milk sugar, present in the condensed milk at its boiling temperature in highly saturated state

The method used for cooling the finished milk varies in different factories (Fig 5) The milk is cooled in ten gallon cans with paddles, the cans revolving in tanks containing the cooling water, or it is pumped through coils submerged in the cooling water or through an internal tube cooler, or the cooling is done in vats with revolving coil. When the cooling has been effected by any of the above methods the milk is transferred to the filling machine Under no circumstances the milk is cooled down below 75°F before filling in tins

Filling in Tins

As the temperature of the milk comes down to 75°F it is transferred to filling machine (Fig. 6). Here tins of marketable sizes are automatically filled in. As soon as this is done the tins are put on with "caps." If allowed to stand open, dust, dirt and flies or other insects are prone to reach their interior, and the prolonged exposure of the condensed milk to the air and light causes the surface to crust over and to develop a tallowy flavour. Hence it is the practice with manufacturers to close the mouth of the tins whout delay.

Sealing

This is the last stage of the whole operation This sealing must be done to keep the tins air-tight and be firm enough to prevent its breaking during transport. For this purpose the side of the cap is first painted with a solution of rosin in petrol and then sealed with molten solder applied by means of sealing machine or soldering iron

PLAIN CONDENSED MILK.

We now pass over to the process of manufacturing plain condensed milk

This is an unsweetened condensed milk. It is made from whole milk, partly skimmed milk or skim milk Its composition of fat and solids varies and is adjusted in the same way as explained under sweetened condensed milk

to conform with whatever trade standard is desired It is condensed in vacuo at a ratio of about 3 or 4 parts of fluid milk to 1 part of condensed milk It is usually super-heated to swell or thicken, and it has the consistency of rich cream Plain condensed mlk is not sterile nor is it preserved by cane sugar Its keeping quality is similar to that of a high quality of pasteurized milk

INSPECTION AND TREATMENT OF MILK

In the manufacture of plain condensed milk the quality and normality of the fresh milk are of even greater importance than the manufacture of sweetened condensed milk The sweeter and purer the fresh milk or skim milk, the better will be the quality of the finished product Efficient inspection of the milk on the receiving platform, is an integral and necessary step in the successful manufacture of plain condensed milk

The milk that has passed inspection is then weighed and sampled, filtered, cooled and collected in the holding tanks where it is standardised to the desired ratio of fat and other solids in the same manner as already described under sweetened condensed milk

FOREWARMING

The standardised milk is then passed through the forewarming process, as it has an important bearing on the successful manufac-

ture of evaporated milk. The temperature and time of forewarming have a marked effect on the heat coagulation point. It is an experimental fact that forewarming at high temperatures (190°F to 210°F) lowers the viscosity and raises the heat coagulation point, and lowers the heat coagulation temperature. In plain condensed milk a high final viscosity is desired, hence low forewarming temperatures are preferable Hence the milk should be heated to temperatures ranging from 140° to 160°F, in order to secure a nice coagulum, when the condensed milk is superheated At high preheating temperatures, the milk does not respond as satisfactorily to subsequent superheating The forewarmed milk is next submitted to the condensing process

Condensing

This is done in the vacuum pan in a manner similar to that described under sweetened condensed milk except that the evaporation is carried further so as to make it highly condensed

Amount of Concentration

The condensation is carried on to widely varying ratios of concentration, depending on the requirements of the trade and on the ratio of fat to other solids

In plain condensed skim milk, the usual range of concentration is between 3 and 4. 1

or a Beaume hydrometer reading at 120°F. of 14 to 18 degrees Be. But the concentration of whole milk is somewhat lower ranging between 2 and 3 : 1 The hydrometer reading in this case, of course, varies not only with the ratio of concentration but also with the ratio of fat to solids. Roughly speaking, it lies between 8° and 11°Be at 120°F

STRIKING

The striking or sampling and testing for density, of plain condensed milk, is more easily accomplished than that of the sweetened milk When this product has nearly reached the proper density, it is not viscous and syrupy, as it does not contain cane sugar or sucrose

In order to test for the termination of the process samples are drawn from the vacuum pan from time to time and its density is determined by means of a sensitive Beaume hydrometer The batch should be "struck" at a uniform temperature, say 120°F., so as to avoid misleading readings of the hydrometer. As the plain condensed milk is superheated before it is drawn from the pan, it is customary to condense it slightly beyond the desired density This is done in order that the solids in the finished product may not drop below the standard desired because of the dilution of the product with condensed steam used in superheating

SUPERHEATING

This is accomplished by blowing "live steam" into the milk in the pan For this purpose the pan is equipped with a direct steam line without pressure reducing valve

Accurate superheating requires experience and judgment. No definite rule of temperature and time can be given that applies under all conditions. The character and concentration of milk influence the heat coagulation point For milk with low heat coagulation point a temperature of 180°F is usually sufficient, while the milk with a high heat coagulation point may have to be heated to as high as 200°F For similar reasons the time of superheating must be regulated in accordance with the behaviour of the milk and the temperature of heating.

As soon as the superheating has produced the desired coagulum, the valve of the superheating steam line is closed, the vacuum pump is started up, water is supplied to the condenser and the pan is operated until the vacuum has returned to 25 to 26 inches and the temperature has dropped to 140°F or below The product is then ready to be thrown out of the pan and cooled

COOLING.

As soon as the plain condensed milk has come out of the pan, it should be cooled

promptly to a low temperature and without the excessive incorporation of air. This product is not sterile, nor does it contain sugar to preserve it In order to prevent souring and other fermentation it must be cooled to temperature low enough to check bacterial activity The great viscosity of this product causes it to hold air that may be incorporated into the condensed milk during cooling This is objectionable because air hastens its deterioration

For these reasons the cooling should be performed with special appliances Vats equipped with revolving discs or vats having horizontal coil are generally used in cooling The horizontal coil vats are so constructed that their lower part is constricted and the coil sets very low in this constricted part, so as to agitate the milk vigorously and at the same time prevent the incorporation of air, by being completely submerged

SKIMMED CONDENSED MILK.

This type of condensed milk is manufactured in the same way as sweetened condensed milk The milk employed in this preparation is only devoid of its cream, which is utilised in the manufacture of butter The skimmed milk is simply warmed and is treated with calculated amount of cane sugar Then the sweetened milk so obtained is condensed in vacuum pan

in the same manner as described under sweetened condensed milk. Samples of milk are occasionally taken out of the pan and tested for the required concentration. When the desired condensation is obtained the milk is drawn off the vacuum pan and is allowed to cool Finally it is put in tins and sealed hermetically.

CHAPTER IX

EVAPORATED MILK.

EVAPORATED milk is cow's milk condensed in vacuo without the addition of sugar and sterilized in steam under pressure.

The first step in the preparation of this kind of milk is to heat the milk to destroy most of the bacteria, moulds, enzymes, etc The temperature to which the milk is subjected is generally higher, and the heating longer, than in the case of sweetened condensed milk

The heating method for sweetened condensed milk may also be applied to evaporated milk. The continuous heater, however, is not suitable in this case, as it is necessary to hold a certain temperature before the milk is sucked into the vacuum pan It is recommended, therefore, that a series of small heaters be provided, rather than one or two large tanks The milk, as it comes from the farms, is allowed to run into heaters and as soon as one is filled it is subjected to heat. As soon as the second heater is filled, heat is applied to it, and so on to the rest of the heater When the milk in the first heater has been heated properly, it is sucked into the vacuum pan for evaporation By the time all the milk in the first heater has

been sucked in, the second must be ready for suction, and so on to the rest When the heater is empty after suction, it may receive a second charge of milk

The milk should be heated without delay A considerable time elapses between milking and receiving at the factory Even with the bese care on the part of producers, the milk is very apt to change considerably during this time, especially in hot season of the year If, for any reason, the heating is delayed, and the milk must be stored for any length of time it should be cooled at once with ice-cold water. or better, with brine, and kept at a low temperature until ready for heating

CONDENSATION.

The condensation is usually done in the vacuum pan in much the same way as with sweetened condensed milk The same vacuum pan, condenser and pump may be used The manner of operation together with every precaution observed in manipulating vacuum pan in the manufacture of condensed milk is essentially the same

The steam should never be turned on to any of the heating appliances until they are completely covered with milk, leaving no exposed heating surface during boiling Foaming and splashing of milk are entirely different phenomena in boiling, as the greatest amount

of foaming occurs when the boiling is not vigorous but the temperature is high enough to evaporate the milk under a partial vacuum. Splashing is due to a partial superheating. When hot milk is first sucked in, it boils rather vigorously at the moment of entering the vacuum pan, but soon settles and begins to foam As the foaming increases, the heating surface is soon covered with milk and a portion of milk is then sucked out through the pump and wasted. When there is violent and high splashing, the milk droplets are thrown out of the pan and finally drawn out to the sewer

Hence in operating the vacuum pan, care must be taken in regard to the rate of suction of supply milk and the turning on of the steam into the heating appliances The rate of milk suction should be fast at first, to insure a quick covering of the heating surfaces After all the heating surfaces are covered and the steam is turned on to full capacity, the suction is regulated to keep the level of milk remaining constant As long as the steam is completely used for heating 25 lbs. or more of steam may be applied to good advantage High pressure steam, however, often causes a localised high temperature at the inlet and consequent coagulation of casein Therefore, the rate of admission of steam should be a little less than in the case of sweetened milk.

The ratio of condensation of evaporated milk is about the same as that of the sweetened milk, being 2 to 2½ parts of fresh milk to 1 part of the finished product.

STRIKING.

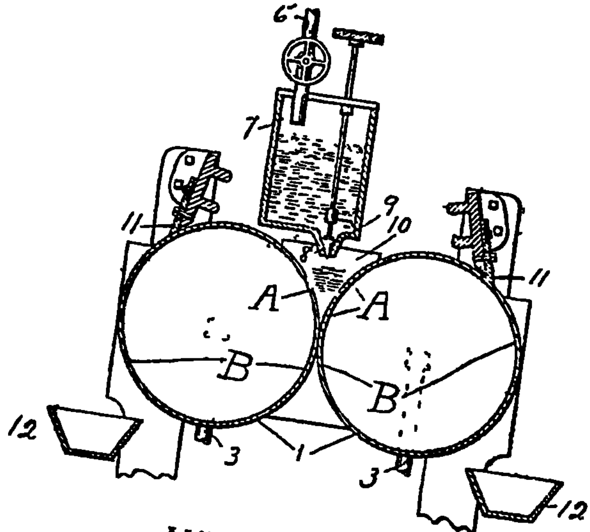
Striking the finishing point of evaporation is much easier in this case than in that of sweetened condensed milk This can be accomplished by testing samples of milk for density with a special Beaume's hydrometer The evaporated milk is not so viscous and syrupy as the sweetened milk; it has the consistency of rich milk and thin cream The density of the milk product is usually taken at 120°F The process is complete when the reading of the hydrometer registers 6° to O°Be

STANDARDISING

The standardisation is better done before condensing Some, however, recommend that the milk be condensed a little beyond the desired concentration and the product standardised to the desired composition, with distilled water, for dilution

If the finished product is to be standardised, the evaporated milk is weighed and put into a standardising vat or tank with some device for agitation, or it may be drawn directly into a vat or tank resting on a scale; thus the

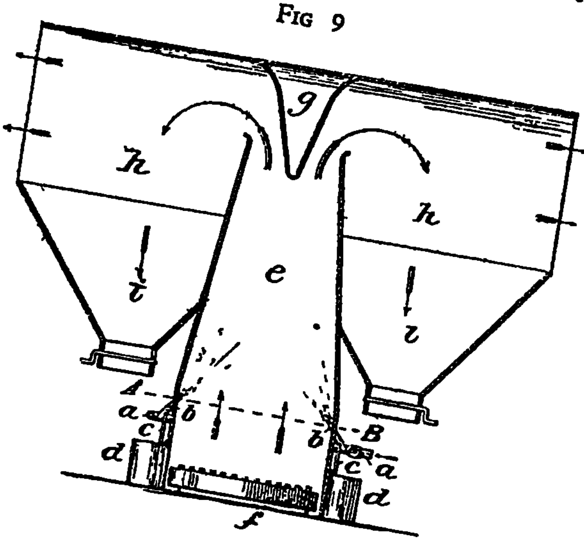
FIG 8



Milk Drying Machine

[*Reference page 1*

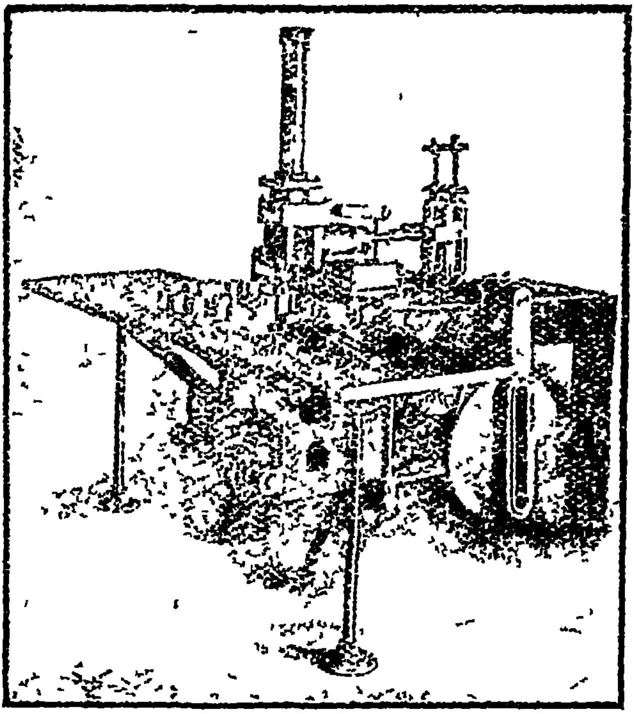
FIG 9



Stauf Milk Drier

[*Reference page 171*

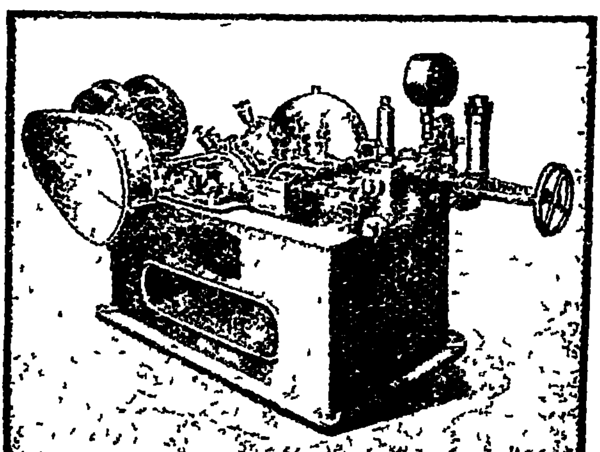
FIG 6.



Filling Machines

[*Reference page 124*

FIG 7



Homogenizer

[*To face page 135.*

amount of evaporated milk can be weighed in a batch

The standardisation of the milk can be conveniently done by Pearson's method. This method is nothing but an application of the following algebraic formula—

$$X = \frac{M-(F-f)}{f'-F}$$

Where X is the weight of standardising material

M is the weight of evaporated milk

F is the standard percentage of fat of the evaporated milk.

f is the observed fat percentage of the evaporated milk and f' is the fat percentage of the standardising material

HOMOGENIZING.

One of the important defects in canned evaporated milk is the separation of fat on keeping. The prevention of this defect is the most difficult part of the manufacture of evaporated milk Preheating, superheating, and high sterilizing heat all help more or less to prevent the fat from separating on keeping; they greatly increase the viscosity through partial coagulation of casein. The best way of accomplishing this object is to use a homogenizer (Fig 7), through which the milk is forced by means of single-acting pumps,

against an agate valve which presses against a ground valve seat The milk has to pass between the ground surfaces of this valve and valve seat.

COOLING.

The evaporated milk should be cooled down soon after it is drawn out of the vacuum pan. Any type of cooler or any system that cools the evaporated milk down to any desired temperature as quickly as possible is suitable for the purpose A surface cooler with or without a cover, may be advantageously used. The evaporated milk from the homogenizer is run over a surface cooler. Where a supply of very cold water is plentiful, the cooling may be done solely with water. Otherwise, the cooler is best made in two sections, and the cooling may be done with cold water at the upper section and with brine at the lower section. With this system, the evaporated milk can be cooled to a very low temperature

CANNING.

The cooled milk is at once filled in cans with the help of an automatic filling machine. There are different types of cans, and machines designed especially to fill them. These cans are provided with a small opening for filling and are filled with a special filling machine The filled cans come out of the machine pro-

perly sealed and are then sterilized as explained before

SHAKING.

During sterilization the milk is subjected to a very high temperature, which causes some milk to curdle in a soft curd Such a product is unmarketable So the sterilized milk is usually shaken in some kind of shaking machine, by which the curd is mechanically broken to a smooth, creamy consistency This operation of shaking reduces the viscosity to the desired point and makes the entire output of a homogeneous appearance

The temperature of the evaporated milk has a great influence on the result of shaking The breaking of the curd occurs much more readily at a higher temperature, hence, at high temperatures, much less shaking is required Too low a temperature, on the other hand, often results in deficient shaking Experience shows that ordinary room temperature is the most convenient and satisfactory for shaking This operation should be continued for a length of time depending on the condition of the sterilized evaporated milk, the temperature, and the manner of shaking Usually, fifteen seconds to two minutes are required On this the evaporated milk keeps without deterioration for a good length of time

CHAPTER X

CASEIN.

CASEIN occurs in the milk of all animals It is employed in many arts and industries as explained on page 36 and forms an important dietary of man.

Casein is an important bye-product that can be manufactured in all dairy farms After the extraction of butter, the residue is usually thrown off. This can however be utilised in making casein

In Northern India, and on the West Coast as well, casein is produced on a small scale, but the quality of the casein produced there is not of the highest class To obtain higher prices for this, it is necessary that Indian technicians take greater pains with its preparation and standardise its quality so that it can meet up-to-date requirements.

PERCENTAGE OF CASEIN IN MILK

To manufacture casein it is quite immaterial whether the milk employed is that of a buffalo, a cow, a goat, an ass, or a sheep In cow's milk it is present to the extent of 2 to 4·5 per cent, the average being 3·2 per cent. All these kinds of milk vary but slightly

from one another and have almost the same composition, and can, therefore, be employed equally well for the production of casein It may be calculated that on an average from 3 per cent to 3 2 per cent of casein can be extracted from skimmed milk

PRINCIPLES OF MAKING CASEIN.

Casein is insoluble in milk and remains suspended in finely divided state Its presence imparts a certain extraordinary physical properties to the milk, notably its viscosity, which influences the rate at which the cream separates out The character of casein is not changed by warming or even by boiling the milk, but on the other hand it is thrown down, by means of rennet or dilute mineral or organic acids The precipitated casein is insoluble in water or dilute acids There are two general methods for manufacturing casein In one method the acids including lactic acid formed as a fermentation product of the milk sugar, will curdle the milk and thus precipitate the casein; and, on the other, the same result can be effected by rennet Of these two processes the former yields pure casein while the latter produces the so-called para casein, a derivative of the old substance

Fat is lighter than water, and after standing it floats on the surface and may be skimmed off The skimmed milk from which the fat

has been removed has no longer a white, but a bluish appearance.

For butter-making in dairies, the fat is separated by quickly-revolving centrifugal churns. After that process the skimmed milk still contains from 0.2 per cent. to 0 3 per cent. of fat, which during the precipitation of the casein augments in the latter even to between 6 per cent and 8 per cent. of contained fat. Such casein is naturally impure, perishable, and of inferior quality. Therefore, after the first separation by the centrifugal machine, from 0.2 to 0 4 per cent of caustic soda (sodium hydrate), heated to a temperature of 40° to 50°C, must be added to the skimmed milk, which is again treated in the centrifuge By this means the contents of fat are reduced to 0 005 per cent. In India the centrifugal machine may have at first to be replaced by hand churning, which will be reasonably satisfactory if the milk is allowed to stand for a sufficient length of time and the operation is performed with great care

The milk freed from fat now contains only casein, lactine and water, and is ready for the precipitation of the casein Casein is precipitated by acids in an insoluble condition. According to the old method, the milk was allowed to turn on its own account, which occurs through its reception of bacteria from

the air, the lactine being converted into lactic acid and naturally being lost. Or rennet ferment from the stomach of a calf, which curdles the milk, is added. But this results in a cheesy, slimy and greasy product of casein which is both impure and perishable and yellow in colour

CURDLING.

With regard to the phenomenon of the curdling of milk or coagulation of its casein, two points are important These are —

(a) If acid is added to milk, casein is precipitated owing to the splitting up of calcium caseinate when the acid combines with calcium, and free casein, being insoluble, is precipitated in the form of a jelly-like flocculent curd Later, this curd contracts and a fluid called 'whey' is expressed out, this is the common 'sour curdling of milk' If lime water or a dilute solution of an alkali is added, casein will be redissolved and the acidity reduced

(b) Rennet or chymosin also curdles milk Here calcium caseinate of the milk is split up by rennet into calcium para-caseinate and a substance called 'whey proteid' Calcium para-caseinate, being insoluble, is precipitated while the whey-proteid is held in solution Certain bacteria also produce a rennet-like ferment which is known as the 'sweet curdling of milk' After the precipitation of casein by

rennet, trypsin begins to act and this digests the curd until casein is dissolved and the mass of curdled milk is liquefied. The curd formed in 'sweet curdling' is firm and solid and not flocculent as in the case of sour curdling This firm and solid condition of the curd is favourable for cheese-making, and for this reason, rennet is so extensively used in cheese manufacture

RENNET AND ITS PREPARATION.

Rennet is an enzyme produced in the stomach, and the curdlings of milk when indigestive is due to this; it is especially abundant in the young while still suckling

Rennet is usually prepared from the fourth stomach of the calf. The stomachs are dried and kept for some time, they are then cut up into small pieces and macerated in a 5 per cent solution, usually containing boric acid, for some days, to the solution a further 3 per cent. of salt is added, and the liquid filtered; this forms extract of rennet By adding more salt the rennet is precipitated; and "rennet power" is produced; this consists, essentially, of the ferment together with other organic matter and a considerable amount of salt.

Rennet acts on casein only in neutral or acid solution, and its properties are destroyed by alkalies Like all enzymes it has an opti

mum temperature at which it acts best. The action of rennet is affected by the acidity of the milk By heating milk the action of rennet is delayed Alkalies destroy the power of rennet to curdle milk; borax acts as an alkali By heating rennet to temperatures much above 60°C it loses its properties rapidly, and it also loses strength by long keeping.

PRECIPITATION WITH RENNET.

In order to secure the correct precipitation of the casein the milk must be kept at a certain temperature, not exceeding 140°F or lower than 68°F., since beyond these limits the action of the rennet is weakened and is very imperfect. In manufacturing casein the milk is poured into a suitable vessel made of enamelled iron and is furnished with mechanically stirring arrangement It is heated to proper temperature when the milk is treated with rennet. At first no change is apparent, but after a time the milk begins to curdle. At a temperature of 95°F one part of good rennet is sufficient to curdle 10,000 parts of milk within forty minutes, while two parts will effect the same result in half the time or curdle double the quantity in the same time. For a given temperature and a definite quantity of milk, the time required for coagulation varies inversely as the amount of rennet used It must be noted here that rennet which

lost its power almost entirely by repeated use, can curdle a fresh batch of milk with much difficulty From this it follows that curdling the milk by rennet must be regarded as a very protracted chemical process, which can only be understood where it has proceeded to a certain stage The stronger the action of rennet and the sooner the casein is thrown down, the more powerful the contraction of the curd and greater the volume of expressed whey.

The casein separated from the milk is termed "curd," and is subjected to further treatment, mainly with a view to reducing its water content when it will be used in cheese-making But if it is intended for technical purposes, it must be thoroughly freed from the residual by repeated washing with water and finally pressed to remove the lost traces of water

In cheese making the curd is vigorously stirred to reduce a uniform pulp with a little water in a large vat. It is then passed through a sieve, after which sufficient water is added to form a milky liquid This is left for the curd to settle down and sieved to drain off the liquid or is put through a centrifugal separator

The washing and draining of the curd is repeated several times, until the washings run away clear, the curd being finally drained in the separator and pressed, if necessary, to

bring it to the proper state of dryness. In this form it can be sent out for various uses, where the presence of traces of moisture does no harm, or else it may be thoroughly dried for conversion into powder The casein obtained by this method is yellow in colour which is regarded as of inferior quality

WHITE CASEIN.

In order to obtain white casein free from yellow tinge, several different acids are used in succession as precipitants The best plan is to throw down the casein in the following manner —

Skim-milk is placed in a vat fitted with stirrers These stirrers are set in motion so as to bring the whole of the liquid into rapid rotation, and dilute hydrochloric or acetic acid is run in by degrees The casein begins to separate out at once in the form of tender white flakes, and the quantity of acid used should be just sufficient for complete precipitation; while continuing stirring a small sample of the liquid is taken, filtered and the clear filtrate is tested with a little acid If it remains clear, then it must be understood that the whole of casein has already been precipitated

The casein is then allowed to settle down and the clear liquid is syphoned off by means of a rubber tube with a glass funnel the mouth

of which is covered with fine gauze and is lowered into the liquid until it reaches the curd. The solid residue in the vat is then stirred up with water, left to settle, the water run off, and the operation repeated twice. The casein, thus sufficiently purified, is placed in strong filter cloths and laid between wooden plates in a screw press. Pressure is now applied to expel water as much as possible As it still contains a large amount of moisture, it is broken up into pieces and spread out thinly on cloths stretched out on frames in the drying-room, the temperature of which is maintained constant at 86°F until the casein is perfectly dry In this condition, the casein will crumble down to powder under the pressure of the finger. Then it is packed and stored in dry room for an indefinite period To eliminate even a trace of moisture which enables micro-organisms to develop in the casein and causes putrefaction the dried product is spread on cloths and sprayed over with a small quantity of pure 95 per cent. alcohol, after which it is immediately packed tightly into square card-board boxes The presence of a trace of spirit hinders the propagation of micro-organism.

PRECIPITATION WITH ACIDS.

Pure acids such as acetic, sulphuric and hydrochloric acids are employed for the precipitation of casein But these are retained

by the casein and require to be neutralised with soda, consequently both the casein and the lactine are rendered impure through the sodium salts combined with the acid. For this reason carbonic acid is used, which, being volatile and escaping from the casein, does not affect its purity. But carbonic acid is weak in its action, and to be adequately effected must be pressed into the milk under a pressure of 30 atmospheres This requires to be done in iron vessel with thick sides, capable of resisting powerful pressure, the obtaining and erection of which is a matter of difficulty in Indian villages. A simpler method, and therefore one that may be conducted with less difficulty, is necessary for India

PRECIPITATION BY SULPHUROUS ACID.

From this point of view the precipitation of casein by sulphurous acid is the easiest and most suitable method, because it has a powerful effect in the destruction of bacteria, and preserves the milk free from contamination during the whole of the process. As far as possible, iron should not be used during the employment of sulphurous acid, because it is to some extent liable to rust, and dyes the casein, which is to be avoided by all means. For this reason earthenware vessels are preferable; another material that could be recommended is the cheap bamboo For the precipitation from

100 litres of milk, 120 grammes of sulphur are sufficient; when it is burnt the sulphurous acid in the form of a gas can be introduced in the finest jets through a spray as it is being stirred into the milk. It is just as easy to saturate water with the sulphurous gas and stir the solution slowly into the milk. Constant stirring is of essential importance. During the process of precipitation the temperature of the milk must be maintained at 50° to 70°C. The actual precipitation is completed in a few minutes.

For the better utilisation of the sulphurous acid, the first tub is provided with a thick cover, so that the superfluous sulphurous acid can be used immediately for the precipitation in a second tub, which may be left uncovered By this means the consumption of sulphur is economised In this method of precipitation the casein is not separated in the form of fine white sand, which can be easily and thoroughly washed by hand One great advantage of precipitation in this way lies in the fact that filter-presses or complicated filtering plants are rendered unnecessary The casein is allowed to settle and the original milk solution is then drawn off in order to be employed for the extraction of lactine.

The casein that has been filtered off is now frequently and abundantly washed with water, until, above all, the whole of the lactine has

been dissolved out of it But as through the use of ordinary water new impurities, such as lime, etc would be introduced into the casein, distilled or rain water is usually employed

Casein of good quality should not contain more than 4 per cent of ash—that is to say, impurities—as the result of the combustion analysis.

DRYING OF CASEIN

It is usual to dry washed casein thoroughly on wooden frames, over which some material of jute is stretched at a temperature of 40° to 50°C A strong heated current of air is passed over the casein Higher temperatures are to be avoided, for then the casein browns and loses its pure whiteness The drying process lasts from ten to twenty hours, because casein contains from 40 per cent to 60 per cent of water Owing to the great quantity of heated air, bacteria have got every chance of again entering into the casein This can be avoided if the heated air is mixed with the superfluous gas (sulphurous acid) which escapes after the precipitation of the casein, which thereby becomes sterilised. This also has the effect of bleaching the casein and rendering it perfectly white Casein when well-dried should contain less than 10 per cent. of moisture, otherwise it will not keep for any length of time The perfection of its quality

is to be recognised by its sandy consistence. Stirring appliances fitted with knives have lately been employed in order to divide the casein during the washing process into the finest sandy grains It should be the special care of the manufacturers that no rancid odour comes out of the finished product.

UTILISATION OF CASEIN.

Although casein has from time immemorial played an important part in the dietary of the human race, its technical utilisation was almost entirely neglected. It is only within the last few years that any extensive technical application of casein has occurred It is used as a paint, as a dressing for textiles, a cement and mucilage, in the production of plastic mass, for sizing paper, and various other purposes Since close attention has been bestowed on the insolubilising action of formaldehyde on casein, a whole series of new uses has been discovered for the articles, which is undoubtedly destined to play a very important part in technology. Furthermore, its original application as a foodstuff has not been lost sight of; its high nutritive value to man and its assimilability have led to the preparation of a number of artificial foods which are now extensively consumed.

CHAPTER XI

CHEESE.

CHEESE brings the larger part of the milk solids together into a condensed form by the coagulation of casein and the expulsion of a part of the water The chief purpose of making cheese from milk is to preserve the nutrients in such form that they may be kept for a long time. With the exception of a portion of the albumin, fat, milk sugar and ash, the solids in the milk are preserved in the cheese It is in fact the curd of milk, salted, dried and compressed into a solid mass

PRINCIPLE OF MANUFACTURE

Cheese making depends upon the curdling of milk By this means milk is separated into two portions—a solid white curd floating at the top of a greenish liquid whey Acid substances, as it has been already shown, readily curdle milk Usually hydrochloric acid, vinegar, cream of tartar have been employed to produce coagulation for cheese-making The curdling is also, in practice, produced by the action of such substances as the juice of figs and other plants But the substance used in all cheese producing districts is rennet (page 142) In order to hasten the coagulating

action of rennet and to produce a curd of sufficient hardness, it is found necessary to heat the milk to a temperature ranging from 72° to 90°F. At the lower temperature, a soft cheese is produced. This product however retains much water and ripens soon At the higher temperature a firm curd and a solid slow-ripening cheese is produced

MODE OF TREATMENT.

Manufacturers should note that for success in cheese making all the pots used must be scrupulously clean and the cows milked in as clean a manner as possible. The evening's milk is strained through two thickness of cloth into the cheese vat, which is kept cool by placing the whole into another vat containing cool water. The milk is left for the night at a temperature of 65° to 70° Fahr The cream is skimmed off in the morning and mixed with warm morning's milk and stirred until melted and it is then passed through a strainer into the vat to be mixed with the evening's milk Before new milk is added the temperature of the old milk is heated to 80° to 84°F—the milk having been gently stirred most of the time since the fire was started, so as to have evening's and morning's milk and cream thoroughly mixed

The best time however to make cheese is immediately after milking. The milk should

first be poured from one vessel to another in some locality where the air is pure and fresh, raising the vessel from which the milk is poured high, so that air can pass through the milk and carry off the animal odour The milk is then poured into a vat and coloured if desired A tea-spoonful of cheese colour to sixteen gallons of milk may be used At this point the milk is heated, if necessary, to make certain it has a temperature of 86 to 89 degrees

The rennet extract at the rate of one ounce to a hundred pounds or twelve gallons of milk is now added. It should first have been diluted in about ten times its bulk of cold water before adding It must be well stirred into the milk. The milk should begin to curdle in from ten to twelve minutes

Great care should be taken not to have the milk at a temperature below 86° when the rennet is put in, and it should not be above 90° afterwards The milk must now be stirred gently until the curd is firm enough to cut. When the curd breaks with a good, clean fracture, it is cut both ways with the curd knife whereby the curd is left standing in half inch columns The heat is now applied and when the columns of curd will break clean over the finger, leaving no soft milky curd, it is gently mixed thoroughly from the bottom to the top by passing both hands under it Then after a

few minutes, as the heat increases to 90° it is cut about as fine as the size of wheat.

After the cutting is finished the curd is gently stirred by hand for about three minutes, then heated slowly to 98° to 100°, constantly stirring gently while the curd is being heated; the curd is kept at this temperature for about forty minutes Curd thus loses its milky appearance As soon as the curd is sufficiently cooked, the whey is drawn off or passed through a curd strainer, and the cheese mould is filled by taking a double handful at a time and pressing gently into the mould, the pressure being continued until the mould is full and well rounded up.

The cheese curd is then taken out of the mould and turned upside down and replaced The cover is put on and the whole is put into the press The cheese remains for a few hours in the press and is then taken out and dressed.

To dress a cheese it is first put into warm water and a piece of cheese cloth about six inches wide and long enough to go around the cheese is wrapped smoothly around the cheese and folded down over the sides; then a cap is put on each side The cheese is then returned to the mould. Both are put under a screw press The cheese is left in the press for about twelve hours, then taken out and salted

SALTING.

The cheese may be either dry-salted or brine-salted Brine-salting is the better way. A solution of salt and water is made as strong as it can possibly be made; the cheese is put in this and salt is sprinkled on the exposed surface The cheese is left in this solution for forty-eight hours, being turned every twelve hours When salted sufficiently long the cheese should be removed from the brine, stripped of cloths, wiped dry and laid on a cellar shelf After about two or three days, when the cheese has become fairly dry on the outside, it should be dipped on the moist surface This also keeps the cheese moist by preventing the evaporation of water

The temperature best suited for curing is from 55 to 65 degrees The cheese will be ready for use in two to four months The lighter the cheese is salted, the sooner will it be ready for use, and the more the curd is cooked, the slower it will be in ripening and the longer it will keep

RIPENING

For ripening, the cheese is put aside in a cool and airy room Time required for ripening is a variable factor In hard, solid, poor cheese the fermentative action responsible for ripening acts very slowly while in those which

contain butter in large proportions its action is energetic.

Cheese when newly made has an acid reaction but by degrees from without inwards the acid action becomes less apparent and ripening starts. When this action is allowed to go long, cheese becomes alkaline and moulds are formed on its surface

The storing of the cheese is an important point for the maker A cool cellar, neither damp nor dry and which is uninfluenced by change of weather or season, is commonly regarded as the best. If possible the temperature should on no account be permitted to exceed 50° to 52°F at any portion of the year

VARIETIES.

Cheese is made from whole and skimmed milk as has been explained on page 39 In certain types of cheese, cream drawn from another source of milk is added during the course of its preparation A few typical recipes of making cheese follow:—

ENGLISH CHEESE.

Mix 10 pounds of cream and 64 pounds of new milk very carefully and bring it to a temperature of 55° to 57°F Enough diluted rennet extract is added to make it coagulate in 24 hours The curd is cut into flat pieces with a skimmer and laid on a linen cloth, which is

folded over it so as to form a press bag These bags or packages are laid in a perforated box with boards between them, and when the first flow of whey stops, the top board is loaded with a heavy weight of some kind This pressing takes 16 to 18 hours as a rule, it should continue until whey ceases to escape The curd is then spread on a large table and worked and kneaded by hand, while adding enough cream to give it a uniform smooth consistency, after this it is left on the table to become firmer The moulding may be done by taking in the right hand enough curd to make a cheese, placing it on a piece of paper and rolling it into a small cylinder or by any moulding apparatus of desired design

FRENCH CHEESE.

The French cheese is made by boiling the milk, adding a little saffron, taking it off the fire and putting it in the rennet immediately The curd is then dried in a cloth, pressed for a few hours, put into a cellar and salted five or six days after, this operation being continued for a month.

DUTCH CHEESE.

The milk is allowed to sour and become loppered or thick Then it is gently heated, which facilitates the separation of the whey The curds are then gathered up, salted or otherwise, to suit the taste, and pressed in small

moulds when it is ready for table. In cool weather when milk does not readily thicken, the sour milk may be put in a suitable vessel set in hot water over the range. The milk is then stirred for a few minutes, when the whey will begin to separate; it is then removed and another batch may be treated in the same way.

RED CHEESE RIND.

It is made by colouring red the rind or the upper part of the cheddar cheese, which is so called because of its originally being made in Cheddar, England. The colours in use are.—

1. Sudan 4 dye dissolved in equal parts of 70 per cent. alcohol.

2. Fuchsin or Bordeaux red dissolved in distilled water.

To be applied to the outside of cheese. The intensity of the colour can be varied by changing the amount of the colouring matter

CHEMICAL COMPOSITION.

The chemical composition of freshly made cheese is as follows·—

	Lowest	Highest	Average
Water	32 69	43 89	36 84
Total Solids	56 11	67 31	63 16
Fat	30 00	36 79	33 83
Proteins	20 80	26 11	23 72
Salts	3 12	7 02	5 61
Percentage of solids in form of fat	50 39	56.83	53 56
Ratio of fat to proteins	1 0 79	1 0 63	1 0 70

CHAPTER XII

MILK SUGAR.

MILK sugar, from which homeopathic globules are manufactured, are in pretty big demand among the homeopathic practitioners The manufacture of milk sugar may therefore form a profitable small industry in the country

This is also used in modifying milk for feeding infants and invalids, as a diluent in various strong drugs, in the preparation of medicinal powders, and in the manufacture of pentanitrolactose which forms a part of some high explosives

HISTORY

Milk sugar is said to have been discovered by accident early in the eighteenth century by a peasant in Switzerland who was making cheese The cheese having been hung up in a bag to drain for some time, this observing Swiss noticed a few crystals that had been formed by the evaporation of the whey A druggist, to whom these crystals were shown, predicted that, if the product could be manufactured in quantities, it would become an important article of commerce. In the first

half of the nineteenth century, milk sugar was being manufactured by very crude methods in Switzerland. Holland and Germany. The sugaring processes occupied about fourteen days, and the product then contained many impurities. But there was great demand for even this impure product and the industry grew Switzerland controlled the milk sugar industry, and supplied the markets of the world.

METHODS OF PREPARATION.

Milk sugar or lactose is probably found in the milk of most mammals and so far as known, is found nowhere else in nature. The milk sugar of commerce is derived from cows' milk of which it forms about five per cent. It is but slightly sweet, hardly hundredth as sweet as cane sugar.

Several methods of its manufacture are described below:—

(1) The bulk of the fat of milk is removed by a separator for butter making, and the "separated" milk heated to from 75° to 85°C and treated with 10 p.c. of milk of lime. whereby the residual fat and casein are precipitated Saturation with carbon dioxide follows, as in the purification of beet root juice and the purified liquid is concentrated and the milk sugar crystallised. It may be purified by dissolution in water and precipitation by alco-

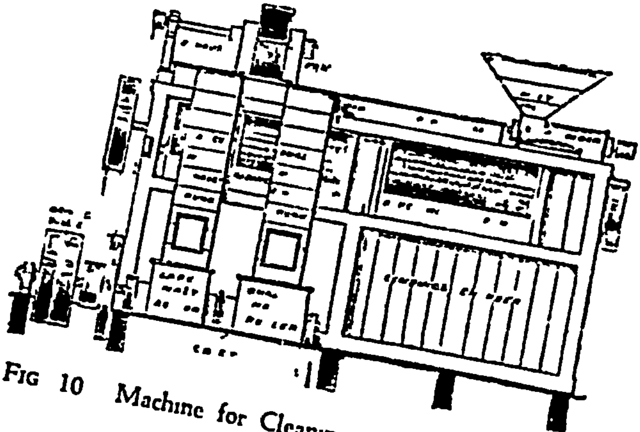


FIG 10 Machine for Cleaning and Grading Barley

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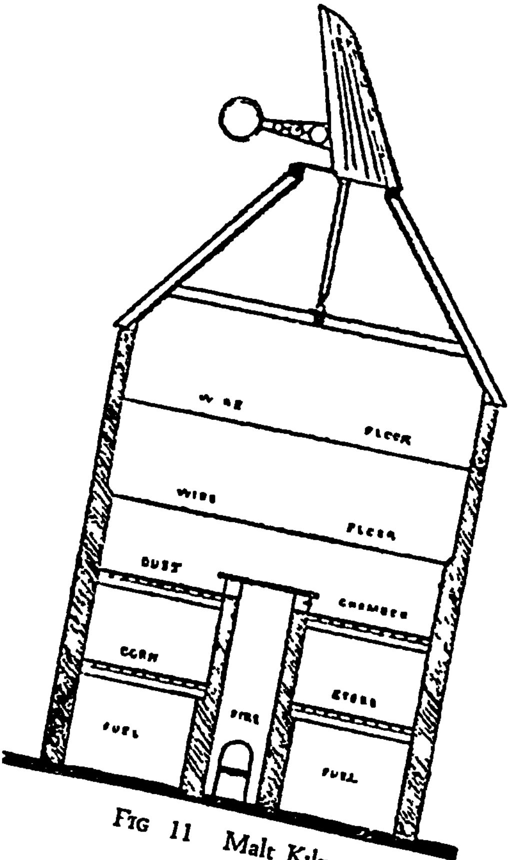

FIG 11 Malt Kiln

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FIG 12

Vacuum Pan for Malted Milk

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hol This may be regarded as a purely pharmaceutical preparation.

(2) The manufacture of crystallized milk sugar has developed greatly in recent years, and a perfectly white well-crystallized product is now obtained For its preparation, the sweet skim milk as it comes from the cream separator is precipitated with acetic acid, filtered, and boiled either in open steam-heated evaporators or in vacuum pans This first boiling should take several hours The whey during the boiling becomes more cloudy, but suddenly clears, and the remaining albuminoid will separate in large flocks It is to be filtered hot and boiled to crystallization in a vacuum pan The raw sugar so obtained can be refined and made white by a process similar to that described above

(3) On a small scale it is best to precipitate the protein from milk or whey by as small a quantity of acid mercuric nitrate as possible The clear filtrate is neutralised with dilute caustic soda solution till a very faint tinge is given with phenolphthalein, it is filtered from the precipitate thus produced, which consists of mercury salts Sulphuretted hydrogen is passed through the clear solution to remove the mercury oxide dissolved by the sugar, and, after filtration from mercuric sulphide, the sulphuretted hydrogen is expelled

by boiling On evaporating the solution, milk sugar crystallizes out, crystallization may be hastened by vigorous stirring of the concentrated solution while it is being rapidly cooled

(4) Whey, acidified to about one per cent. of hydrochloric acid, is heated in large vats to the boiling point with steam. This precipitates the albumin The solution is then made neutral with calcium hydroxide, evaporated in a vacuum pan to a syrupy consistency (25°Be) and filtered through a series of cloths in a high-pressure filter press. When sufficient syrup has accumulated, it is again run into the vacuum pan and evaporated, at about 110°F, to a much richer syrup This latter is drawn out into shallow boxes, where it cools and crystallizes, in 24 to 48 hours, into what appears to be a yellow sand This is crude sugar, and must be refined by repeated recrystallization.

(5)' Sugar of milk is prepared by the addition of diluted sulphuric acid to the whey of cows' milk, and by subsequent evaporation. the albuminous matter is coagulated; this is filtered out and the liquid set aside to crystallize Animal charcoal is sometimes used to decolorise the solution

PRINCIPLE OF PREPARATION.

Milk sugar is generally prepared from whey when milk is used for making casein or

cheese The whey remaining behind contains:

Milk sugar	4 6 to 5 0%
Protein (chiefly albumin)	1 0%
Fat	0 3%
Mineral substances	0 6%

When whey is boiled the albumin coagulates, and as the process is continued almost to dryness a crude variety of milk sugar is obtained When an enormous quantity of whey is obtained, as in cheese or casein factories, the evaporation is conducted in vacuum pans instead of ordinary boiling pans This impure milk sugar contains 85 per cent. of milk sugar, 10 per cent of water, and nearly 5 per cent of mineral matter, along with small amounts of protein and fat

The whey must be worked as quickly as possible, otherwise fermentation may set in, the milk sugar being partially decomposed into lactic acid, which in its turn at once converts the major portion of the remaining milk sugar, thereby occasioning a serious loss to the manufacturers The addition of a little sodium carbonate solution so as to neutralise most of the acid tends to prevent loss of milk sugar by inversion, care being taken to keep the liquid to remain very faintly acid The addition of a few grains of formalin in place of sodium carbonate also acts well, but is somewhat expensive

Sour milk must be carefully neutralised before concentrating. Then the whole is gently evaporated until the lactose crystallises on cooling The evaporation takes place at 60°—70°C in vacuum pans. As the water boils away, fresh whey is allowed to pour in continually at such a rate as to maintain the level of the liquid constant The liquid thus gradually concentrates to 30°—32°Be., when it contains 60 per cent. of solid matter; it is then run out into crystallizing tanks of sufficient capacity and allowed to cool In summer this cooling must be hastened by surrounding the tank with cold water The temperature must come down from 60°C to 20°C in 24 hours A coarse-grained pasty mass of crude milk sugar crystals separates out at this stage The whole is then transferred to a centrifugal machine where the crystals are separated from the magma. There passes away from the centrifugal machine about one-third of the original mass as a syrup still containing a large percentage of milk sugar, which is generally extracted by bubbling live steam through the liquid of density 15°Be This coagulates the albumin, which collects on the surface and is left behind as a cake when the syrup is run off The cake is next pressed between folds of cloth, ground, mixed with potatoes, turnips and used as a food for pigs

The syrup at 35°Be, thus freed from albumin, is once more run into the vacuum pans, concentrated, allowed to crystallize after standing for several days in well-cooled vessels, diluted with water and treated with a centrifugal machine This produces a further yield of 0 3 to 0 7 per cent of impure milk sugar The total yield of crude milk sugar is about 4.35 per cent.

The liquid left after the separation of the second treatment can be used as manure It still contains albumin and non-crystallisable sugars, but it cannot be used for feeding pigs as it produces disorder of bowels Lately, it has been wrked for lactic acid and calcium phosphate

Another way to obtain the crude milk sugar is to neutralise, or nearly so, the acid of the whey with sodium or ammonium carbonate, then boil, when the coagulated albumin rises to the surface along with the fat, in the form of scum This is skimmed off and the liquid can be easily evaporated in a vacuum

PURIFICATION OF THE MILK SUGAR.

The crude yellow milk sugar thus obtained is sometimes dried and sold as such More often it is purified For this purpose the impure substance is dissolved at 50°C with stirring in a steam heated copper boiler The solution contains 24-27 per cent of milk

sugar (13°-15°Be). Animal charcoal and 2 per cent. of acetic acid is added to precipitate albumin, the solution warmed nearly to the boiling point, some magnesium sulphate is added to precipitate phosphoric acid, and the liquid is boiled for a few minutes. The liquid foams. The temperature rises to 105°C. A sediment collects at the bottom The liquid is pumped upwards into a copper vessel covered with wood, and then allowed to flow downwards through filter presses. The clear liquid so obtained is concentrated in vacuum apparatus to 35°Be. Any foaming is stopped by adding a little fat and increasing the pressure Finally the concentrated liquid is run into iron crystallizing vessels, cooled, and the separated milk sugar is centrifuged. The mother liquors are further worked for sugar The milk sugar thus obtained is further refined by dissolving it in water to 15°Be, heated to boiling, a small quantity of aluminium is added and the liquid is passed through filter press It is again concentrated to 32°Be, cooled in copper vessels, centrifuged, and the resulting white sugar is dried in rotating inclined cylinders in a current of hot air, cooled and lastly ground to powder

CHAPTER XIII

MILK POWDER.

MILK powder is made from cow's milk to which sugar or alkalis or salts may or may not have been added and which has been evaporated to dryness either under atmospheric pressure or in vacuo

All attempts to dry milk by processes such as those used in condensing milk, and involving the treatment of the milk in bulk for a considerable period of time, have resulted in a product of very inferior quality In the prcoesses now in use the milk is treated in the form of films or spray for a relatively short time

There are various processes used in the manufacture of milk powder, of which the following are advantageously employed, namely —

1 Dough-drying system
2 Film-drying system
3 Spray-drying system

DOUGH-DRYING SYSTEM

In dough-drying system the milk is first condensed in any manner, either by heating in open pans under atmospheric pressure or in the

vacuum pan The concentrated product is subsequently ground to a fine powder.

FILM-DRYING SYSTEM.

The film apparatus in common use comprises a rotating cylinder, on which a thin layer of milk is evaporated to dryness in the course of a single revolution In Ekenberg's process the temperature is low and the operation is effected in vacuo. Kunick also uses a low temperature, but facilitates the evaporation by means of a current of air The Just-Hatmaker process is probably the most interesting and successful of this type

In this system the milk or milk products, with or without previous concentration, is conveyed to the surface of the drum in such a manner as to cover the drum with a thin film This may be done by the use of reservoir extended over the entire length of the drum on its under-side. The milk to be dried is adjusted at a level sufficiently high to cause the drum at its lowest side to dip into the milk During each turn the revolving drum picks up a thin film of the milk fluid The water present in the milk evaporates with the heat in the drum The drum rotates slowly enough to permit the film to practically dry by the time the drum has made a complete revolution Then the dried milk film is automatically scraped off by the stationary

knife or scraper and the product drops into a trough from which it is removed by an endless carrier It then goes to the grinder and bolter where it is reduced to a fine powder.

A temperature in excess of 100°C is maintained on the surface of the cylinder, and the milk is in consequence reduced to dryness so rapidly that injurious changes are inhibited The time during which the milk is exposed on the surface of the cylinder is never more than 2½ seconds, and may be as low as ½ second

A variation of the above method is to drop concentrated milk between two horizontal steam-heated revolving metal cylinders. The apparatus used is known as a twin-cylinder drying machine and is shown in Fig 8 It is composed of two cylinders placed side by side and slightly separated from each other so that there is contact in the periphery The milk, fed continuously to a trough constituted by the upper parts of the cylinders and suitable end walls, is carried round as a film on the surfaces of the cylinders There are scrapers or knives for removing the dried milk from the cylinders, and close to the bottom there are receptacles to receive the finished powder The cylinders are heated internally by means of steam of 40 lbs pressure In consequence of the temperature used, this process has the

additional advantage of providing a sterile product

SPRAY-DRYING SYSTEM.

In spray system of drying milk, milk is sprayed into a chamber of hot air The spraying of the milk in the drying chamber is performed by either forcing the milk under high pressure through a series of fine spray nozzles or spraying it by centrifugal force The minute units of the finely divided milk readily give up the moisture to the hot air and deposit on the sides and bottom of the hot air chamber in the form of snow-like dry milk flakes.

The fluid milk is used with or without precondensing, but any previous concentration of milk very materially increases the rapidity of drying Most of the precondensing is done by the use of the vacuum pan or similar standard milk condensing equipment It can however be most economically done by passing the hot air escaping from the drying chamber through a preliminary spray of the fluid before that milk reaches the drying chamber

To produce the sprays the milk is forced under high pressure through one or through a series of very fine spray nozzles Sometimes when the spray is produced by centrifugal force, the milk flows in a thin film over

a rapidly revolving disc and is thrown to the walls of the drying chamber Spraying is carried on successfully by the Stauf Patent Process (Fig 9) The figure shows a vertical drying chamber (e) into which the liquid milk to be desiccated is sprayed through jets (b) under pressure, into a fine spray A current of heated air is admitted at the bottom of the drying chamber (f) This runs in the same direction as the spray of milk and evaporates the watery constituents of the spray The steam and dried particles are carried upward by the heated air, retaining the atoms momentarily in the current of hot air and causing them to surrender substantially all the remaining moisture in the form of vapour The vapours and dried atoms are guided by a cone (g) extending downward from the top into the drying chamber, into collecting chambers (h) There the desiccated milk or dry powder gathers in hoppers (i) away from the vapourising current The moisture-laden air is separated from the dry powder and escapes through the sides of the collecting chamber

It is important that the dried milk should be removed from the hot drying chambers promptly so as to retain the valuable properties of the original milk as much as possible For this purpose the chamber is furnished with a mechanical carrier in order to remove the dried

milk product automatically as fast as it is formed.

In a recent process, carbonic acid gas is used as a drying agent in order to impart keeping qualities to the product

BOLTING AND PACKING.

The powdered milk made by spray-drying process requires no grinding It is of flowery make-up and after sifting is ready to be packed The film-dried milk comes off from the drying drums in sheets It is ground and bolted before packing As the product is very hygroscopic, it is packed in air-tight tin cans.

USES.

13 oz of milk powder dissolved in 7½ pints of water make 1 gallon of skim milk

9 lbs butter and 2½ lbs. of milk powder added to 3 gallons and ½ pint of water make 4½ gallons (37 lbs) of 20 per cent cream

CHAPTER XIV

MALTED MILK.

THE convenience, nutritive value and digestibility of this product recommend themselves to and are appreciated by the medical profession, and its relishing properties appeal to the public.

The industry has therefore grown rapidly; its prosperity has attracted many manufacturers of dairy products, so that to-day malted milk is made by numerous firms and their annual output is assuming large proportions India consumes a large portion of these products It is only recently that some industrialists have ventured to take up the line.

MANUFACTURE OF MALTED MILK.

The manufacture of malted milk divides itself chiefly into three phases. First, during malting of barley one has to do with the cleaning, steeping, germinating of the barley, and the drying of the barley malt Secondly, the manufacture proper consists of preparation of the mash of barley malt and wheat flour, conversion of the starch into maltose and dextrin by enzymic action, separation of the hulls from the barley malt, addition of whole

milk or whole condensed milk. Thirdly, the article is finished by condensing, drying, grinding and packing ready for the market.

The purpose of malting is to produce a sufficient quantity of diastatic enzymes to completely and rapidly convert the starch of the grains into soluble, easily digestible and readily assimilable maltose and dextrin Barley malt is generally used for this purpose because of its pleasant and agreeable flavour

SELECTION AND CLEANING OF BARLEY.

To prepare malt, the barley is subjected to a thorough screening to free it from foreign seeds, broken kernels, dirt and other impurities and imperfections (Fig 10).

STEEPING THE BARLEY GRAIN.

The cleaned barley grain is next soaked in water until the water has completely penetrated them For this purpose tanks are used, in which it is wetted down with enough water to be completely submerged The water stands one to two feet deep above the grain and is kept at a temperature of about 68°F. The water is changed at intervals of about eight hours, so as not to become sour or stale The steeping occupies from 24 to 48 hours The frequency of changing the water and the duration of steeping vary somewhat with malt house and season of year.

The steeping tanks are cylindrical and taper towards their bottom The bottom is equipped with a screened water outlet and an opening for dropping the grain into a chute leading to the germinating floor below

During the steeping process the barley kernel swells up considerably, taking up much water so that it now contains approximately 45 to 50 per cent. of moisture Some grains. consisting mainly of oats and inferior barley kernels, generally rise to and float on the surface of the water of the steeping tank These floaters are skimmed off, dried separately and sold as cattle feed

GERMINATION OF BARLEY

There are three systems of handling the steeped barley grain during the germinating process The wet grain is either spread out on a plain floor (cement or tile floor) or it is placed in long bins with perforated bottoms (Saladin or pneumatic trough system), or it is placed in horizontally revolving drums (Pneumatic drum system)

In each system control of moisture and temperature is important These two factors determine the extent to which diastase and other enzymes develop The desired moisture is provided by sprinkling water on the germinating grain and the temperature is controlled

by the depth of the barley mass and by agitation and air circulation.

The germinating process occupies from 5 to 7 days. In order to properly germinate the barley in 5 days a temperature of about 70°F. is maintained in the barley mass. This requires a temperature of the circulating air of about 60° to 65°F. This is further facilitated by the saturation of the air with moisture and sprinkling the grain with water when needed The beginning of the germinating period is often spoken of as the *coutching* This is to allow the grain to warm up to the proper germinating temperature During the coutching no water is added The successful germinating process depends largely on the judgment of the malt maker who decides from the length and appearance of the acrospires, and the mellowness of the grain centre, when the production of diastase has been carried to the right point The barley, when properly germinated, should contain a pure white starch centre, and the acrospire should be about three-quarters of the length of the kernel The kernels should be mellow. Fine rootlets are present at the germ end or base of each kernel at this stage

KILNING OR DRYING THE BARLEY MALT

The germinated barley is now transferred to the kiln for drying and arresting further

germination The kiln (Fig 11) consists of a vault with fire box or furnace at bottom and one or more grated and adjustable doors for exit of vapours The removal of vapours is generally accelerated by suction fans placed at the air outlets In the case of kilns with more than one floor, the wet grain is placed on the upper floor in layers from one to two feet deep Heated air from below is drawn through the barley and it is raked and turned by slowly moving mechanical turners, in order to facilitate uniform drying at a temperature of from about 80° to 110°F. After drying for one to two days the floor grates on which the grain lies are opened and the grain is permitted to drop to the lower floor Here the drying is completed at a temperature ranging from about 120° to 150°F This final drying is accomplished in one to two additional days The dried grain is then dropped through the floor grates and transferred to screens where the newly shrivelled, hair-like rootlets are fanned off

The degree of heat used and the length of time the grain is exposed to it in the kiln determine the colour of the malt The more heat, the darker the colour In the case of barley malt intended for the manufacture of malted milk a light colour is desired In order to prevent the finished product from assuming a brown colour the kilning tempera-

ture is, therefore, held as low as possible preferably 120°F or below

The dried grain, with its rootlets removed, is now called barley malt The external appearance of the barley malt is not unlike that of the original barley grain But inside, immediately underneath the husk, we now have a small sprout called the acrospire

This product, the barley malt, is now ready for use in the manufacture of malted milk The first step in malting consists of mashing

PREPARING THE MASH.

The purpose of the mashing process is to convert the insoluble starch and protein contained in the wheat flour and in the barley malt into soluble carbo-hydrates and protein-derivatives

The proportion of malted barley and wheat flour varies with different manufacturers It is claimed that 10 per cent. barley malt contains enough diastatic strength to invert all the starch in the wheat flour, but it takes longer to convert the starch completely when the proportion of barley malt is small

Barley malt is higher in price than wheat flour Other conditions being the same, the exclusive use of wheat flour, therefore, would lower the cost of manufacture. Wheat flour alone could be malted, but barley is desired

because it is said to contribute certain desirable compounds to the finished malted milk.

The starch as contained in the original wheat flour is insoluble in cold water and is not acted upon by diastatic enzymes. It is, therefore, necessary to first render it soluble. This is done by boiling up the wheat flour in hot water. During boiling the starch cells swell and burst, forming an opalescent paste in which the starch is present in the form of so-called soluble starch. The wheat flour paste is then cooled as preliminary to the mixing with the barley malt. Before mixing, the barley malt is crushed by running it through a malt mill which is of the roller type. The purpose of crushing is to open the grain and make the diastase edibly accessible to the starch. The grain should not be reduced to a finer powder, as this hinders the subsequent separation of the hull from the barley malt liquid, but the crushing should be sufficiently complete to expose the contents of each individual grain.

The crushed barley malt is then mixed into a mash with the wheat flour paste. The end products resulting from the mashing process and its reactions that are most desired, are complete conversion of the starch into relatively high maltose and low dextrin content, together with reduction of the original grain proteins into simpler and more readily

digestible compounds. This may be accomplished by heating the wheat flour-barley malt mixture for one-half hour at 40°C (113°F), then raising to 70°C. (158°F) at the rate of one degree centigrade per minute, which would require 25 minutes, and then holding at 70°C for one hour. Desired variations in the end products may be obtained by slight modifications of exact temperatures and time exposures

SEPARATING THE HUSKS FROM THE MASH.

As soon as the mashing process is complete the hulls are allowed to settle and the liquid portion of the mash is removed This liquid extract of the mash contains incolloidal substances which do not dissolve when the malted milk is mixed with water

ADDING WHOLE MILK TO THE MASH EXTRACT.

The mash extract is now mixed with fresh whole milk, and mixture is condensed and dried. The relative proportion of mash extract and whole milk is such as to cause each pound of dried malted milk to contain an amount of milk solids equivalent to 2 2 pounds of fluid whole milk This represents an approximate proportion of 40 to 45 per cent. whole milk to 55 to 60 per cent mash extract The exact proportion varies somewhat, depending on the amount of available milk.

Small quantities of salt, such as sodium chloride and sodium and potassium bicarbonate are usually, though not always, added to the malted milk mixture before drying

DRYING.

The condensing and drying of the malted milk mixture is accomplished in several ways, either in a vacuum pan (Fig 12), equipped with mechanical stirrers or on drying drums enclosed in a vacuum chamber, or even by the spray drying process, all of which have already been discussed Great care is taken to guard against exposing the product during the drying process to high temperature which would injure the dietetic value of some of its ingredients

It is stated that in the manufacture of malted milk of the best quality, the product is not subjected to temperature above 130°F to 140°F during the drying process In some factories the malted milk is first condensed in ordinary vacuum pans equipped with powerful agitators, the operation of which requires from 60 to 80 H P towards the completion of the drying process A high vacuum is maintained (about 27 inches) and in the final stages of drying the doughy mass swells up and becomes porous

When dried in the vacuum pan with agitator the finished product comes out of the

pan in the form of large chunks which have a brittle, porous, honeycomb-like make-up The product coming from the drum driers resembles shreds of paper which readily fall apart.

The spray-dried malted milk is flaky The malted milk of the vacuum pan drying process and that of the drum-drying process are ground before filling into containers The grinding and filling should be done in a perfectly dry room, as malted milk is very hygroscopic and becomes wet and gummy rapidly upon exposure to humid air. It is for this purpose the grinding and packing are preferably done in a refrigerated room to prevent contact with humid air at ordinary temperature, that would make the product damp, gummy and sticky In order to insure dry air, the air before entering the grinding room is passed over ammonia expansion coils where it deposits its moisture and similar coils are also installed in the grinding room.

MALTED MILK POWDER.

Malt Extract powdered	5 oz
Skimmed Milk, powdered	2 oz
Sugar, powdered	3 oz

Mix thoroughly by shaking and rolling in a dry can. Pack in an air-tight container

CHAPTER XV

KHOA.

KHOA, the Indian condensed milk, constitutes one of the chief ingredients of sweet-meats and is thus in large demand It is obtained by partially evaporating the moisture from whole milk

PROCESS OF MANUFACTURE

An idea of preparing khoa has already been offered on page 46. This can be made from whole milk but in some cases it is made from skim milk left after the separation of cream, for ghee making

This is made by boiling fresh (whole) milk in an open pan placed over a fire until it attains the consistence of syrup During boiling sugar is sometimes added Of Bengal districts, Tippera is spoken of as producing khoa of special quality An expert says, "The flavour of this preparation depends on (a) the quantity of milk boiled at a time, (b) the care with which the milk is stirred at the time of boiling, and (c) the nature of the heat applied

To obtain khoa as white as possible, and possessed of the best flavour, not more than

half a seer of milk should be boiled at a time. All the time the milk is boiling it should be stirred with a wooden rod. Some prefer to stir with a number of rods. A strong and steady heat should be applied Tamarind wood is considered the best fuel for this purpose When the milk has got thickened, it is stirred briskly with a wooden spatula and allowed to cool It is finished up in the form of small balls or pats, each weighing about 2 to 3 lbs

Khoa of an inferior quality is sometimes made from fresh butter-milk To get khoa of a fine white colour, a little flour or arrowroot is sometimes added to the milk during the boiling operation When thick enough it is removed and allowed to cool, when it is ready for sale It has been recently upheld that *the khoa made from separated milk is also as* good and marketable an article as that from whole milk, and hence the double profit in the khoa and the butter Thorpe and other scientists have pointed out that the action of sugar in desiccated milk is preservative, but for this purpose 12 per cent of the weight of the milk must be sugar

For khoa manufacture, buffalo milk is largely in demand because cow milk not only makes yellowish khoa, but lacks body and texture The outturn from cow milk is also less compared with that from buffalo milk.

Occasionally, khoa may be made from goat milk and sometimes from skimmed milk There is no specific demand for the latter types of khoa and they are not of commercial importance They are usually made with a view to finding a market for goat or skimmed milks, and sometimes for making a product for mixing with khoa made from buffalo milk

USES.

The manufacture and use of khoa are confined mostly to western and northern India In Mysore, Cochin and Travancore States, Madras Presidency, Nizam's Dominions, Central Provinces and Orissa, it is not much used. In the United Provinces, about a tenth of the total production of milk is converted into khoa This is due to the large number of cities and towns and also to the large number of melas which are held periodically at the several places of pilgrimage in the province Many lakhs of persons assemble at these centres For them, thousands of sweetmeat shops spring up temporarily and nutritious sweetmeats made from khoa are sold in large quantities

With a large supply of milk India can easily do a large trade in the production of khoa and in milk boiled down to a powder, and can thus put a stop on the imports of condensed milk

CHAPTER XVI

DAHI OR CURDLED BOILED MILK.

THE names most generally given to thickened or coagulated or specially soured boiled milk are dahi, dadhi, khoya, mava, tyre, etc

Dahi is usually prepared by throwing boiled and partially evaporated milk into a vessel *that has contained dahi, but has not been* subsequently washed At other times a certain quantity of dahi or some other acid substance called a starter is added to the boiled milk, or a vegetable or animal rennet is employed

Formation of *dahi* depends on fermentation of milk, in course of which lactic acid is produced. Milk undergoes a number of other fermentations besides that of *dahi* The particular fermentation it will undergo depends on the conditions under which this takes place

It is only when the milk is kept at a certain temperature and when a given quantity of dahi of a particular degree of sourness is mixed with it, that the dahi fermentation takes place properly The extraneous germs of which the atmosphere is full are of course to be excluded from it

SOURING MILK WITH LACTIC ACID.

In order that the milk should become sour, it is necessary that germs of lactic acid fermentations should gain access to it, and that a temperature favourable to their normal development should be secured The presence of the germs may be left to chance inoculation, or they may be artificially supplied. Under ordinary conditions, when the cream has been separated from the milk, a sufficient number of germs of fermentation settle in the milk to cause a rapid production of lactic acid, though the number will vary from day to day and from time to time, and a certain amount of acid cannot be depended upon within any given specified time The inoculation is more certain, and the desired degree of acidity will be more surely reached, at the end of a given time, if the germs are added in sufficient quantity artificially The source of the inoculation may be in the form of an artificially prepared "Starter" of sour milk, or it may be in the form of any of the so-called commercial lactic ferments It is desirable that none but the proper germs should find access to the milk and, in relying upon natural means, there is always more or less danger that putrefactive and other undesirable ferments may gain access to the cream Between the various forms of artificial starters, there is not much to be said It is generally held that a starter

made from sour milk is less likely to contain germs other than those desired than when whole milk, or even butter-milk are used

PREPARATION OF DAHI.

To prepare dahi, milk is heated in an open pan and made to boil briskly. The milk is then stirred with a ladle. The operation is stopped when froth appears on the surface In the meanwhile a number of earthenware pots, shallow and wide-mouthed, are kept ready These should be preferably new and when old vessels are to be re-used, the inner side should be cleaned perfectly well and charred by burning a quantity of straw within The vessels in all cases should be clean Hot milk is then poured into the pots, which may be of any desired capacity up to 10 seers Starters are then put in the vessels, which are placed on shelves of a room which should be rather warm To preserve the heat, the vessels may be wrapped with blankets

Certain preparations of dahi contain a good proportion of sugar, usually 1 part of sugar being added to 4 parts of milk during boiling.

VARIETIES.

When the milk is boiled immediately as obtained from the cow and is curdled, it contains all its fat or butter. In this form it is

called *sara*, and if kept hot may be accumulated for some days till sufficient has been collected to form it into dahi This is therefore called *basa-dahi*.

If butter be removed from the dahi by churning, the liquid that remains is *butter-milk* or *ghol-dahi* (matha, lassi) But a top layer of the dahi may be simply skimmed off and used in the manufacture of butter Hence there may be whole-milk dahi (basa-dahi), skimmed milk dahi, as well as butter-milk (ghol-dahi)

Dahi in the liquid state is largely consumed; its whey called *mastu* contains all the milk-sugar and the curd (chhana) may or may not have embedded in all the butter-fat Whole-milk dahi thus contains too much fat to be made into cheese It is, in fact, *cream-cheese*, and some localities such as Bandel near Hughli and Dacca in Eastern Bengal are famous for their cream-cheeses When acid or rennet is added to the hot milk, this is called *dud-chhena*, but dahi is often heated and allowed to cool in order to prepare imitation curds known as *dahi-chhena* The whey (as it may be called) of dahi is separated by pressing the dahi-chhena within a clean cloth, but if it be completely dried the chhena crumbles to a powder

Dahi is also the first stage in the manufacture of ghee

USES.

Dahi prepared for sale is generally made from buffalo milk, because it gives a firmer texture and does not break up when cut and sold in small lots The curdling pan commonly used is an unglazed earthen vessel. In Travancore State, there is comparatively an important trade in dahi Every evening, small earthen pots of dahi are brought in bullock carts from the villages to the large towns In Trivandrum, there is a market-place used exclusively for this product, where nearly 600 to 700 earthen pots (about 2 gallons capacity each) are brought on bullock carts from surrounding villages for sale every evening In Madras Presidency, as much as 11 per cent of the total production of milk is marketed in this form ·Plain dahi and curried preparations form quite an importont item in the diet of the people of the South In the North, dahi is beaten up into a drink called lassi to which may be added salt or sugar Cold lassi is a very popular summer drink, particularly in the Punjab

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